# New Scientist

**WEEKLY** 20 January 2024

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WHY SPERM COUNTS ARE FALLING AND WHAT WE CAN DO ABOUT IT

**IS THERE A BLACK HOLE IN THE SUN?**

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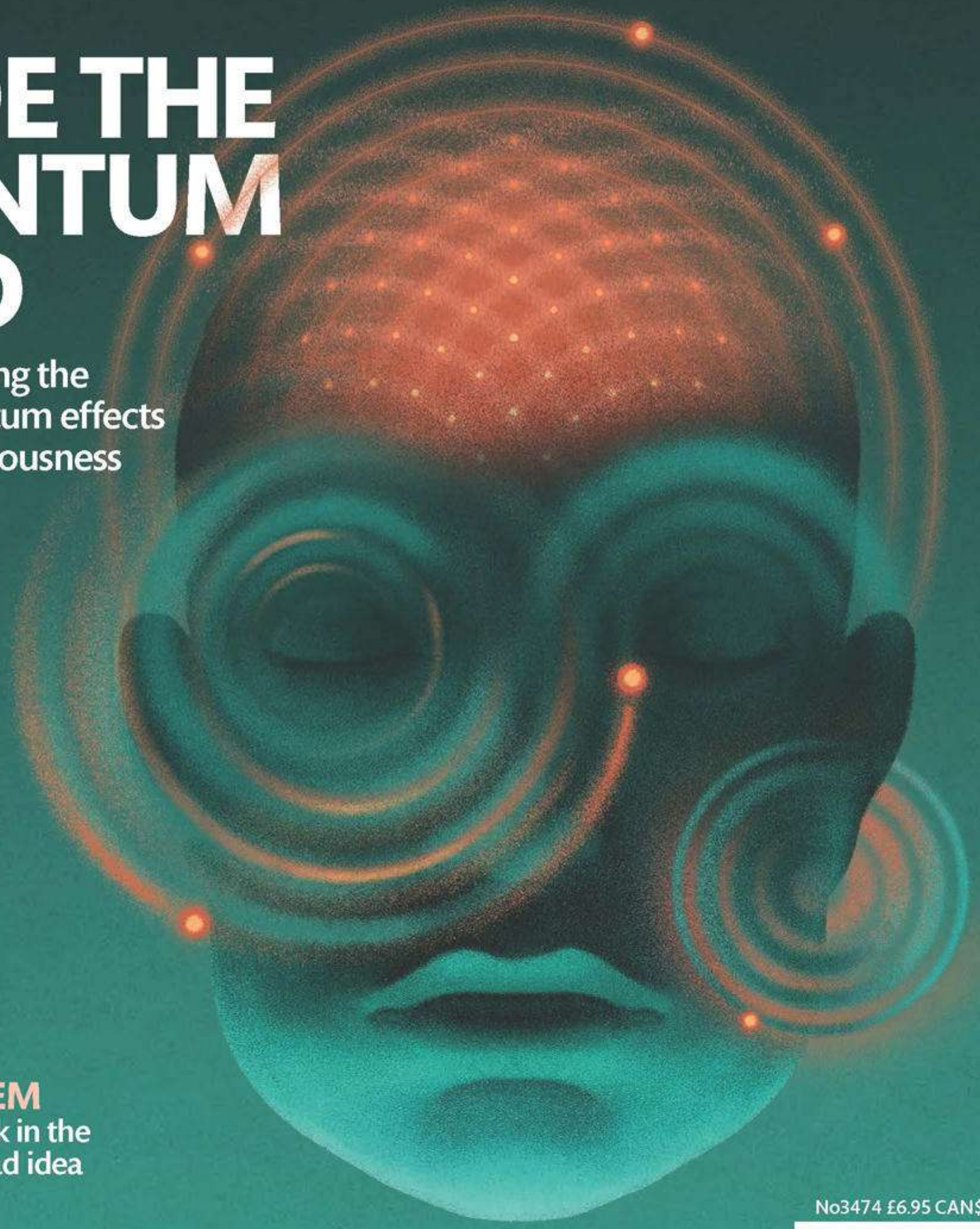

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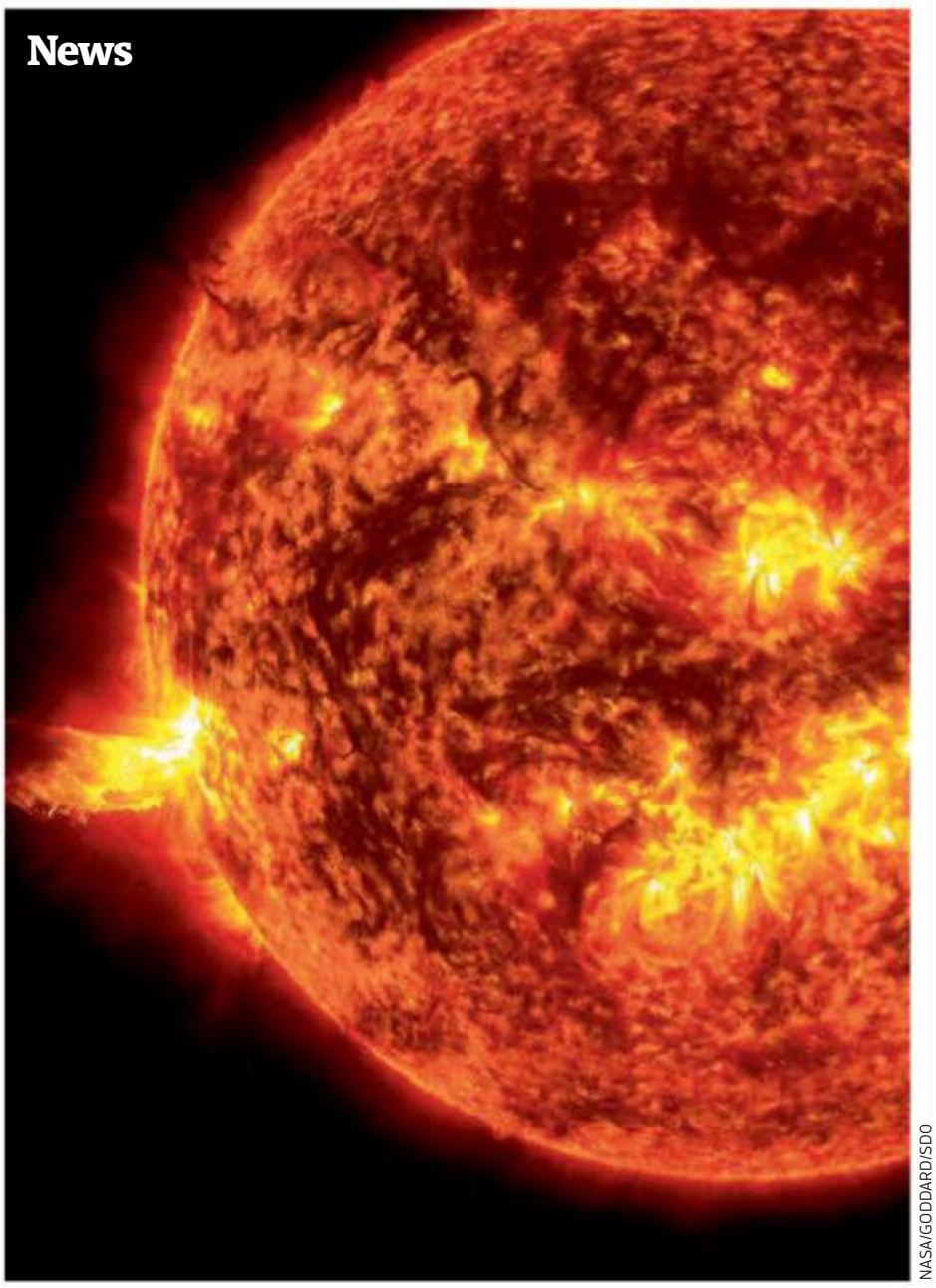


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### The road to conscious machines

Public debate about the future of AI is often centred on the idea of a dystopian robot takeover. Michael Wooldridge, a computer scientist at the University of Oxford, will instead explore how our anxieties distract us from the immediate risks that this technology poses – from algorithmic bias to fake news – revealing the real, life-changing potential of AIs. This subscriber-only event takes place on 12 March at 6pm GMT/1pm EST.

**newscientist.com/events**

## Tour

### Wildlife conservation of Sri Lanka

Go in search of leopards and forest elephants, as well as more unusual species such as sloth bears, pangolins and lorises. Visit a turtle conservation centre in Rekawa village, then head out blue whale watching with an expert marine biologist. This 12-day tour starts on 18 March and costs £3999.

**newscientist.com/tours**

## Podcast

### Weekly

The team discuss how lasers have led to the discovery of ancient cities in the Amazon rainforest. They also cover how theorists may be close to cracking Stephen Hawking's black hole information paradox. Plus, AIs may have found a way to make more sustainable lithium-ion batteries with only a fraction of the lithium in standard batteries.

**newscientist.com/nspod**

IDDP

**Krafla volcano** Magma could supercharge geothermal power

SHUTTERSTOCK/GIVAGA

**Elephant encounters** Travel around the wildest corners of Sri Lanka

## Video

### Magma hole

Go behind the scenes of feature writer Graham Lawton's recent article, which reveals how scientists in Iceland are planning to drill two boreholes into a reservoir of liquid rock. This daredevil mission in the Krafla volcanic system will give us our first direct measurements of magma – and could be developed into an unlimited source of clean power.

**youtube.com/newscientist**

## Newsletter

### Our Human Story

How do non-human primates, our closest living relatives, live with disabilities in the wild? The answer isn't straightforward, as many of the misconceptions, prejudices and tropes about people with disabilities have been carried over into research about animals with disabilities, finds Michael Marshall.

**newscientist.com/our-human-story**

## Podcast

**"It might not be true that everything that falls into a black hole gets sucked in forever"**

## Essential guide

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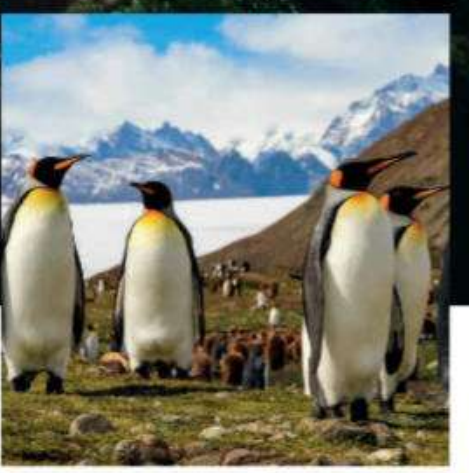

## Rewilding in the Côa valley: Portugal

**29 April 2024 | 6 days**

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## Whale watching and marine ecosystems in the Azores Islands: Portugal

**May 2024 | 7 days**

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## Ecology expedition through the Amazon and Pantanal: Brazil

**26 September 2024 | 13 days**

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## The science of Antarctica: South Georgia, Falklands and Antarctic cruise

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# Quantum thoughts

## Ambitious attempts to explain consciousness should be given a fair chance

THE idea that quantum phenomena in the brain can explain consciousness has persisted for decades on the fringes of mainstream research. There is something appealing about an attempt to explain consciousness with something similarly mysterious, which might tell us why this proposal has also enjoyed more than its fair share of press attention over the years.

There are plenty of good reasons to be sceptical, of course, not least the absence of any solid expehrimental evidence. But that isn't to say that hypotheses about quantum consciousness have no value.

As we explore on page 32, researchers have started to put one of the most popular of these, known as orchestrated objective reduction (Orch OR), to the test in experiments that make use of anaesthetics to dial consciousness up and down. The results, hinting at quantum effects in brain cells, are intriguing if resoundingly inconclusive. Now, they are about to probe the idea further in clusters of lab-grown neurons called brain organoids, which offer a more realistic testing ground.

**"Results hinting at quantum effects in brain cells are intriguing, if inconclusive"**

All of which is sufficient to warrant a second look at Orch OR, at least. Even if this flurry of results fizzles out and the idea as a whole turns out to be wrong, it is already showing its value. For example, researchers are now asking what kinds of quantum information processing could have evolved in living systems. On a more practical level, the latest findings may have implications for how doctors administer anaesthetics.

Above all, we should remember that this is still a fledgling field. One of the most popular mainstream explanations for consciousness, known as integrated information theory, was recently branded "pseudoscience" because it can't be ruled out straightforwardly. That is unfair because the same could be levelled at most ideas to explain this phenomenon. When it comes to the origins of consciousness, we shouldn't expect straightforward solutions. Which is why we should give ambitious ideas like Orch OR a fair chance, even if they may ultimately fall away. ▮

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ROV SUBASTIAN/SCHMIDT OCEAN INSTITUTE

Marine biology

## A shimmering tangle of limbs

**Multiple glass octopuses (*Vitreledonella richardi*) are entwined here, but researchers don't know if they are eating each other or mating. This beautiful picture was snapped by a remotely operated vehicle launched from the Falkor (too) research vessel. The ship's expedition has also discovered four new deep-sea octopus species living on underwater mountains about 3 kilometres down off western Costa Rica.**

**Analysis** Cloning

# Does the birth of a cloned monkey mean we could now clone people?

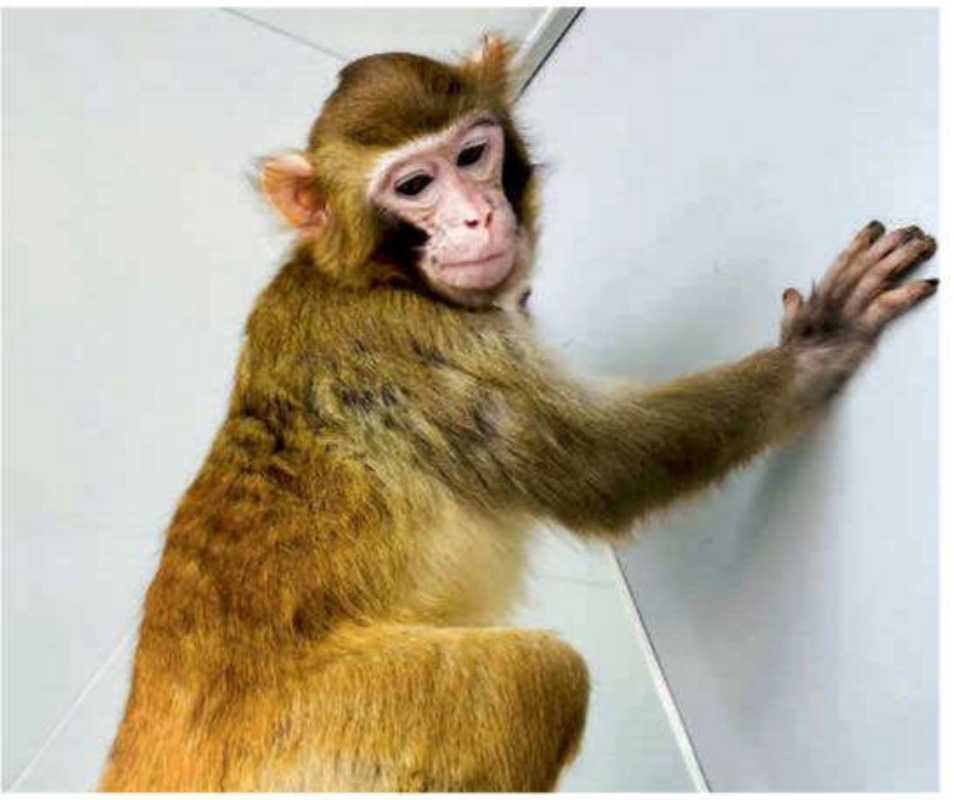
A healthy rhesus monkey has been born after being cloned from fetal cells, but creating a clone of an adult human being would be much harder, finds **Michael Le Page**

AFTER numerous attempts over the years, a healthy rhesus monkey has finally been created through cloning. The clone was born in China on 16 July 2020, but its existence has only now been revealed.

"The cloned rhesus monkey has reached the age of 3," says team member Falong Lu at the Chinese Academy of Sciences in Beijing. "So far, we haven't observed any health issues in it by our routine physical check-ups."

However, the monkey was cloned from fetal cells rather than adult cells, and the embryo had to be provided with a non-cloned placenta. So despite this advance, cloning primates remains extremely challenging. As a result, it still might not be technically possible to create a clone of an adult human being, quite apart from the ethical and legal issues.

Cloning is the creation of an individual that is genetically identical to another individual. It is simple to clone plants, but with most animals, it is far trickier.



ZHAODILIAO ET AL.

**This rhesus monkey, aged 3, developed from an embryo made with cloned cells**

## From Dolly to dogs

The first mammal to be cloned from an adult cell, Dolly the sheep, was born in 1996. Since then, researchers have tried cloning many mammal species with mixed results.

In a few, cloning works relatively well. One team in South Korea has cloned more than 1500 dogs so far, for instance, although the success rate remains low: less than 4 per cent of the cloned embryos result in a live birth. With many other mammal species, cloning fails altogether or produces unhealthy animals.

The main problem is that, as cells in the body develop and specialise, various so-called epigenetic markers get added to their DNA to turn certain genes on or off. When an adult cell is cloned by putting it in an empty egg, it usually has the wrong epigenetic markers.

Primates – the group including monkeys, as well as apes such as humans – have proved particularly tricky. While there have been several previous reports of cloned monkeys, in every case so far there have been big caveats.

For instance, a rhesus monkey born in 1999 is sometimes described as the first primate clone, but this individual was created by splitting an embryo – as happens during the creation of identical twins – rather than by cloning an adult cell as with Dolly.

**<4%**

**Proportion of dog clone embryos that result in a live birth**

In 2022, the birth of a rhesus monkey cloned from a genetically modified adult was reported, but this clone died soon after birth.

The most successful attempt until now was the birth of two long-tailed macaques in 2017. The researchers behind this work used a chemical cocktail to help reset the epigenetic markers, but they were still able to clone only fetal cells, not adult ones.

Lu's team tried applying the same cocktail to rhesus macaques, but the only clone born this way didn't survive. The researchers concluded that abnormalities in the cloned placentas were partly to blame, so they developed a new technique that involves transferring the part of an early embryo that turns into the fetus – the inner cell mass – into a non-cloned embryo from which the inner cell mass has been removed (*Nature Communications*, DOI: 10.1038/s41467-023-43985-7).

This means the cloned fetus develops inside a non-cloned placenta that is genetically different to it. In theory, the resulting fetus could be a mix of cloned and non-cloned cells, but the team discovered no evidence of this.

Even with the help of this intricate technique, however, the team has so far cloned only fetal cells, not adult ones. In other words, no healthy primate has yet been created by the cloning of adult cells.

**"The act of cloning a human being is completely unacceptable. We won't think about this"**

This means it remains an open question whether it is possible to make a clone of an adult human. Lu wouldn't speculate about whether his team's technique might help. "The act of cloning a human being is completely unacceptable. We won't think about this," he says.

Shoukhrat Mitalipov at Oregon Health & Science University, who also works on cloning but wasn't involved in this research, says it is unclear whether the technique could help create a cloned human. "Aside from the ethical issues, it is unknown if human [cloned] embryos have any placental abnormalities," says Mitalipov.

Lu says the purpose of cloning primates is to advance research. "Rhesus monkeys are a vital and commonly utilised non-human primate laboratory animal in the field of cognitive and biomedicine research," he says.

For Mitalipov, the aim is to use cloning to generate matched stem cells in order to treat individuals. "In our case, we hope that someday doctors will be able to use rejection-proof, genetically matched embryonic stem cells to replace diseased nerve, muscle, blood and other cells, or to produce eggs to treat infertility," he says. ▮

Earth

# Siberia's mysterious craters may have been carved out by hot gas explosions

James Dinneen

DEEP, cylindrical craters in the permafrost of Siberia have puzzled researchers since they were discovered over a decade ago. Now it seems the distinctive structures may appear when warming temperatures weaken the permafrost in conjunction with a build-up of hot, methane-rich gas, which then explodes to the surface.

"Climate change is likely the triggering factor, but it happens there because you have the thinning of the permafrost due to the gas," says Helge Hellevang at the University of Oslo in Norway.

As permafrost continues to thaw, more of the explosive craters could form, posing a threat to oil and gas infrastructure in the region, as well as representing an uncounted source of planet-warming methane emissions. Exploding craters could release gas trapped beneath the permafrost as well as gas generated within it.

The first of these holes – now called gas emission craters – was discovered in 2012 in Russia's Yamal peninsula. At least seven others have since been identified in the region, although many more might have formed and then frozen over. Some are more than 50 metres deep and 20 metres wide. "These features are really quite spectacular," says Hellevang. "Almost completely circular, and big and deep."

Researchers have put forward a number of explanations for the craters. Some propose that they formed when thawed areas inside the permafrost expanded and filled with methane and other gases also generated from within the permafrost.

But Hellevang and his colleagues argue that such scenarios don't explain why the craters only appear to form in one region of the Arctic. He also says that processes within the permafrost couldn't generate the amount of gas required to produce such violent explosions: some of the craters are ringed by bus-sized chunks of ice thrown hundreds of metres away from the hole.

VASILY BOGOYAVLENSKY/AFP VIA GETTY IMAGES

**One of several enormous craters discovered in remote Siberia**

Instead, Hellevang and his team propose that the craters are due to hot, methane-rich natural gas welling up from a deeper source, such as a geological fault in the sediment below the permafrost. In their model, the heat from the gas thaws the permafrost from below, while warming atmospheric temperatures weaken it on the surface, eventually triggering an explosion (EarthArXiv, doi.org/mcq2).

"I think their idea makes sense," says Lauren Schurmeier at the University of Hawaii. However, she says the researchers lack observations from a crater to back up the process they describe, and that more than one process could be behind the craters.

But if the new model is right, it might suggest the craters are more than just a geological curiosity. An increase in such craters due to global warming would be an uncounted source of climate-changing methane emissions. "You're dumping a lot of methane in a very short time," says Thomas Birchall at the University Centre in Svalbard, Norway. ▮

Technology

## The first unhackable shopping payments on quantum internet

**RESEARCHERS have demonstrated how secure quantum e-commerce could work on the unhackable quantum internet of the future.**

**Hua-Lei Yin at Renmin University of China and his colleagues built a small network from five quantum computers connected with several kilometres of fibre. This worked by tweaking the quantum properties of light pulses travelling between the computers so that it is nearly impossible to intercept the transmitted information without destroying it.**

**Then the researchers gave each machine a role. One played the merchant, two others could act as buyers and the remaining two served as neutral mediators to prevent any party from lying.**

**The quantum computers communicated by sharing sequences of quantum light signals called quantum encryption keys. To engage in e-commerce, the merchant generated a contract that both it and a buyer had to verify and sign. Each step of their communication went through a third-party mediator first. As a trial contract, the researchers transmitted a file the same size as the Amazon Web Services customer agreement: around a million bits.**

**In about 1 second, the merchant and client could complete the contract signing process 11 times (*Science Advances*, doi.org/mcq4). Yin says this is faster than similar protocols for quantumly secure transactions that have been suggested in the past, and closer to the speeds of traditional communication networks.**

**11**

Number of times machines could complete contract signing per second

**Khodakhast Bibak at Miami University in Ohio says the work combines two existing quantum encryption protocols, which creates a very secure e-commerce set-up.**

**But adapting this protocol to networks larger than five users may be challenging, says Hoi-Kwong Lo at the University of Toronto, because it will need an impractically high number of encryption keys at the start of the process.** ▮

**Karmela Padavic-Callaghan**

Solar system

# Islands on Titan may be icebergs

## Ephemeral "magic" features in the moon's seas may be made of odd clumps of snow

Leah Crane

THE seas on Saturn's moon Titan have weird "magic islands" that seem to appear and disappear over the course of hours to weeks. These features might actually be porous, sponge-like clumps of snow that slowly fill up with fluid and then sink.

Titan's thick atmosphere is full of complex organic molecules that can clump together and fall to the moon's surface like snow. Xinting Yu at the University of Texas at San Antonio and her colleagues thought the "snow" could be responsible for the magic islands.

NASA/JPL-CALTECH/STÉPHANE LE MOUÉLIC, VIRGINIA PASEK

**An infrared image of the surface of Saturn's icy moon Titan**

### Methane seas

To test their idea, Yu and her colleagues used what we know about these atmospheric compounds and how they should interact with Titan's seas.

Typically, we expect any solids on the surface of these seas to sink immediately because the liquid on Titan is methane rather than water. While water molecules tend to cling to one another and push away other materials, methane easily grabs onto other molecules, so a pool of liquid methane has very little surface tension to resist sinking.

"Water molecules just love themselves to the exclusion of some types of molecules," says Michael Malaska at NASA's Jet Propulsion Laboratory in California, who wasn't involved in this work. "But put methane on the same surface and it will crawl all over." That means the methane oceans and lakes on Titan should immediately swallow up any solids, even those that might otherwise be expected to float.

But that clearly doesn't happen with the magic islands, which appeared as relatively short-lived bright spots in observations from the Cassini spacecraft. "For us to see the magic islands, they can't just float for a second and then sink," Yu said in a statement. "They have to float for some time, but not for forever, either."

The researchers found a solution to this problem: if large chunks of snow amassed on the shore, they could form ices that are full of holes, like sponges. When these porous "icebergs" broke off from the land, they could float on Titan's seas for long enough to match the Cassini observations.

Yu and her colleagues calculated that this would work if the sponge-like structures contained enough empty space – a minimum of about 25 to 50 per cent depending on the exact composition of the ice (*Geophysical Research Letters*, doi.org/mctk).

> **"For us to see the magic islands, they can't just float for a second and then sink"**

This doesn't mean that the mysterious islands are definitely porous icebergs, though. "We are narrowing the different scenarios for the magic islands, but we still don't yet know the answer," says Malaska. Other possible explanations include bubbles of nitrogen gas, waves caused by wind or solid sediments in the oceans. But this does provide evidence that Titan's transitory islands could actually be floating matter from this strange world's atmosphere. ▮

Technology

# AI comes up with battery design that uses less lithium

**ARTIFICIAL intelligence has helped researchers develop a battery from scratch in just months that is less dependent on lithium – a goal of materials science for years.**

**Lithium-ion batteries power many devices we use every day as well as electric vehicles. But the metal they rely on is expensive and mining it damages the environment, so people have been seeking alternatives.**

**Now, Nathan Baker at Microsoft and his colleagues have created a battery that uses up to 70 per cent less lithium than some competing versions, and they accomplished the task in months with the help of AI.**

**The researchers focused on a type of battery that only contains solid parts and looked for new materials for the component that electric charge moves through, called the electrolyte.**

**They started with 23.6 million candidate materials designed by tweaking the structure of established electrolytes and swapping some lithium atoms for other elements. An AI algorithm then eliminated the materials that it calculated would be unstable, as well as those in which the chemical reactions that make batteries work would be weak.**

DAN DELONG/MICROSOFT

A researcher tests batteries that use a new material designed by AI

**The researchers picked one of the AI's shortlisted materials to synthesise in the lab. It stood out to team member Vijay Murugesan at the Pacific Northwest National Laboratory in Washington state because half of what he would have expected to be lithium atoms were replaced with sodium.**

**His team built a working battery with this material, albeit one with a lower conductivity than similar prototypes that use more lithium (arXiv, doi.org/mcth). However, Murugesan says the battery could be improved. And the process of making it – from the first time he spoke to the Microsoft team to the battery being able to turn on a light bulb – took just nine months.**

**The team used AI to accelerate calculations that physicists have been doing for decades, says Rafael Gómez-Bombarelli at the Massachusetts Institute of Technology. "The methods here are bleeding edge, in terms of machine-learning tools, but what really elevates this is that things got made and tested."** ▮

Karmela Padavic-Callaghan

Technology

## A breath 'fingerprint' could be used to unlock your phone

Matthew Sparkes

**THE air turbulence created when we breathe could be used as a biometric test for unlocking smartphones or other devices. And unlike other tests, such as fingerprint scans, it can't be passed by a dead person.**

**Mahesh Panchagnula at the Indian Institute of Technology Madras, Chennai, and his colleagues recorded 10 breaths from each of 94 volunteers, using an air velocity sensor to take readings 10,000 times a second. They fed that data into an artificial intelligence model, intended to identify people with breathing difficulties who might benefit from medication.**

**The researchers found that the model, once it had analysed someone's breath data, could verify whether a new breath came from that individual with more than 97 per cent accuracy.**

**In a second test, where the model was asked to identify a breath without first being told who might be providing it, it was able to correctly identify the person as one of two possibilities more than 50 per cent of the time (arXiv, doi.org/mcrd).**

**Panchagnula says the AI model is detecting unique patterns of turbulence caused by the different shapes of each individual's extrathoracic region – made up of the nasal and oral passages, pharynx and larynx.**

**He adds that the results can probably be dramatically improved with refinement, but that the findings show the concept is viable. Although many biometric systems already exist, Panchagnula says a breath test would have one unique advantage: it only works on living people. Some news reports suggest that the smartphone of a deceased individual can be unlocked using their fingerprint. But a breath-based system would be safe from this.**

**"You can't make a dead person pass this test because you need the person to exhale," he says.** ▮

Health

# Pregnancy makes brain regions shrink, but most regrow again

Grace Wade

SOME brain regions become smaller and thinner during pregnancy and most of these changes reverse after giving birth, scans reveal. This suggests the brain is restructuring itself during and immediately after pregnancy, potentially to prepare for parenthood.

"Pregnancy is probably the most intense hormonal event that a human being can go through. So, it was reasonable to think the brain will change during pregnancy," says Susana Carmona at the General University Hospital Gregorio Marañón in Spain.

Previous studies involving a small number of participants have shown pregnancy alters the structure and organisation of some brain networks. To investigate further, Carmona and her colleagues scanned the brains of 110 first-time mothers during the third trimester of their pregnancy, and again within a month after they gave birth. They also scanned the brains of 34 women who had never had children.

**A mother's brain undergoes significant changes around a birth**

FATCAMERA/GETTY IMAGES

The scans revealed changes in the cortex, or the outer region of the brain, during and after pregnancy. On average, the cortex was 2.5 per cent thinner and 4.6 per cent smaller in volume in pregnant women than in the women who didn't have children. Most of these differences reduced in the period after birth, except in

**4.6%**

**How much smaller a cortex was, on average, in pregnant women**

two brain networks called the default mode network and frontoparietal network. Regions in these networks were at least 2 per cent thinner and almost 3.6 per cent smaller in volume in new mothers than in women who didn't have children (*Nature Neuroscience*, doi.org/mcrb).

The default mode network is important for self-perception and social interaction, and the frontoparietal network is used in executive functions like planning and carrying out tasks. More data is needed to elucidate why pregnancy alters these networks, but one widely accepted hypothesis is that these changes help prepare for parenthood, says Catherine Monk at Columbia University in New York.

Cortical thinning also occurs during puberty as the brain refines neuronal pathways, in a process called synaptic pruning. Some pathways are effectively closed off while others are built into efficient speedways. This could be why the cortex thins in pregnancy and after birth, too, says Monk.

It would make sense for the brain to refine pathways in the affected regions to facilitate empathising and caring for a child, says Carmona. "If you ask any mother, most of them will tell you, 'I feel completely different [after giving birth].' These changes might be behind this feeling, but we still don't know," says Carmona.

Yet the fact that most cortical changes reverse after birth suggests another mechanism is also at play. Carmona says this might be widespread decreases in microglia, the brain's immune cells. "Your whole immune system has to adapt so you can gestate a person that is genetically different from you, and we know that microglia change shape and number pretty quickly," she says.

The findings could also help us understand mental health conditions associated with pregnancy, like postpartum depression, says Carmona. "It's important to realise that parenting begins before birth," says Monk. "There's so much brain plasticity and change happening that we could get in there, then, to promote optimal well-being. And that could help families get off to a better start." ▮

Archaeology

# Amazon hides ancient megalopolis

Researchers reveal that a mysterious civilisation built a network of cities and roads in the rainforest between 3000 and 1500 years ago, and then vanished, finds **Michael Le Page**

THE largest pre-colonial cities in the Amazon yet discovered, linked by an extensive network of roads, have been glimpsed in aerial surveys.

"The settlements are much bigger than others in the Amazon," says Stéphen Rostain at the French National Center for Scientific Research in Paris. "They are comparable with Maya sites."

What's more, at between 1500 and 3000 years old, these cities are also older than other pre-Columbian ones discovered in the Amazon. Why the people who built them disappeared isn't clear.

It had often been assumed that this rainforest was largely untouched by humans before the Italian explorer Christopher Columbus reached the Americas in the 15th century. In fact, the first Europeans reported seeing many farms and towns in the region.

These reports, long dismissed, have been backed up in recent decades by discoveries of ancient earthworks and extensive, fertile dark soils that were created by farmers. One estimate puts the pre-Columbian population of the Amazon as high as 8 million.

## Hidden by trees

Rostain and his colleagues have been studying archaeological sites in the Upano valley of the Ecuadorian Amazon, in the foothills of the Andes, since the 1990s. Traces of ancient settlements were first found there in the 1970s, but only a handful of sites have been excavated.

In 2015, Rostain's team did an aerial survey with lidar, a laser scanning technique that can create a detailed 3D map of the surface beneath most vegetation, revealing features not normally visible to us. The findings, which have only now been published, show that the settlements were more extensive than anyone realised.

STEPHEN ROSTAIN

**Lidar scans of the Upano valley in Ecuador showing raised platforms that once hosted buildings**

This work reveals the existence of more than 6000 raised earthen platforms within an area of 300 square kilometres. These are where wooden buildings once stood: excavations have revealed post holes and fireplaces on these structures (*Science*, doi.org/gtc9dt).

Most platforms are about 10 by 20 metres and 2 metres high, and are thought to be the former sites of houses. The largest is 40 by 140 metres and 5 metres high, and may have hosted monumental buildings used for ceremonies.

STEPHEN ROSTAIN

**Stéphen Rostain at an archaeological site in the Upano valley, Ecuador**

Around the platforms were fields, many of which were drained by small canals dug around them. "The valley was almost completely modified," says Rostain.

Analysis of pottery suggests that maize, beans, manioc and sweet potatoes were grown.

Overall, there were five major settlements in the area surveyed. They could be described as garden cities, says Rostain, due to their low density of buildings.

The lidar also revealed a network of straight roads created by digging out soil and piling it on the sides. The longest extends for at least 25 kilometres, but might continue beyond the surveyed area.

What is peculiar is that the Upano people went to great lengths to make the roads straight, says Rostain. In places, they dug down 5 metres rather than follow contours, for instance. So the roads probably had symbolic significance, as there was no practical reason to make them straight, he says.

There are also signs of defensive structures such as ditches in some areas, so there may have been some conflict between groups.

In the rest of the Amazon, many settlements were abandoned after the arrival of Europeans, probably because diseases and violence unleashed by the invaders killed a large proportion of the population.

All the Upano artefacts dated by Rostain's team are older than 1500 years, however, suggesting that the settlements in the valley were abandoned after this time, long before the colonial era. Why isn't clear, but the team has found layers of volcanic ash, so it is possible that a series of eruptions forced people to leave the valley.

**"This is the largest complex with large settlements so far found in Amazonia"**

"This shows an unprecedented degree of complexity and density of settlement for this early time frame," says Michael Heckenberger at the University of Florida. "The authors justifiably conclude that the complexity and scale are comparable with better known cases, such as the Maya, at this time."

"This is the largest complex with large settlements so far found in Amazonia," says Charles Clement at the National Institute of Amazonian Research in Manaus, Brazil. Furthermore, it was discovered in a part of the region that other researchers had concluded was sparsely inhabited during pre-Columbian times, says Clement. ▮

Health

# Covid-19 variant JN.1 may be the mildest form of the virus yet

Clare Wilson

SOME of the recent news stories about covid-19 have felt reminiscent of the first two years of the pandemic. Due to a variant called JN.1 – sometimes called Juno – infection rates have been rising in many countries, with some initial claims that it could cause more serious illness.

But in fact, the latest figures from England show that people who get infected in the current wave are less likely to become sick enough to need hospital treatment than in previous waves.

This suggests that, on average, those who catch covid-19 have less to worry about than at any other time during the pandemic, says Paul Hunter at the University of East Anglia, UK.

JN.1, another version of the omicron variant, was first detected in Luxembourg in August 2023 and spread to numerous nations. Genetic sequencing showed it was significantly different from most previous versions of omicron and, by November, it became apparent that JN.1 was rapidly taking over.

Those observations led to concerns that JN.1 would cause a large wave of covid-19 over the northern hemisphere's winter, when hospitals would also be coping with high numbers of people with other seasonal respiratory viruses, such as flu.

In December, claims were made that the JN.1 wave was causing more severe illness, as many people haven't had a covid-19 vaccine for some time.

In the UK and many other European countries, autumn 2023 boosters were offered only to older people or those who met certain criteria, such as being medically vulnerable. Even in countries such as the US, where the vaccines are available to everyone older than 6 months, uptake has been low.

As concerns over JN.1 mounted, there were calls to bring back various public health restrictions against covid-19. Some hospitals in the UK and the US, for instance, have reintroduced face masks in public spaces and last week Spain made mask wearing compulsory in all healthcare settings.

**Spain has reinstated the wearing of masks in hospitals**

MARCOS DEL MAZO/LIGHTROCKET VIA GETTY IMAGES

Fortunately, the warnings of bigger waves haven't been borne out so far. And in England, the current wave is causing less severe illness than ever before, as judged by the number of people the coronavirus is sending to hospital compared with the number who are known to be infected.

For instance, the number of people testing positive for covid-19 in England amid its current wave seems to have peaked in mid-to-late December, at about 4.5 per cent of the population, according to a survey by the UK Office for National Statistics and the UK Health Security Agency.

This is a similar proportion to that seen during the covid-19 wave that peaked in December 2022.

Yet the number of people being admitted to hospital primarily due to covid-19 seems to have peaked this winter at just over a third of the equivalent figure from the previous year – at about 1300 earlier this month, compared with around 3300 a year ago.

"I think immunity is probably playing a big role, but it may be that the latest variant is also less virulent," says Hunter.

Astrobiology

# Molecules vital for life could survive in Venus's acid clouds

**AMINO acids can survive in concentrated sulphuric acid similar to that found in Venus's clouds. This doesn't make Earth-like life more likely in these clouds, but it does open the possibility of a kind of life based on sulphuric acid instead of water.**

**Whether Venus's clouds can harbour life has been hotly argued, especially after phosphine, a molecule produced predominantly by living organisms, was spotted in the planet's atmosphere – though that result was later questioned.**

**Now, Sara Seager at the Massachusetts Institute of Technology and her colleagues have found that 19 amino acids used by life on Earth to make proteins are relatively unaffected when placed in concentrated sulphuric acid similar to that found in Venus's clouds.**

**They discovered that 13 of the amino acids were unchanged by a 98 per cent solution of sulphuric acid, with the remaining six undergoing modification of the molecular "side chain", which is the part of the amino acid that determines its chemical properties (arXiv, doi.org/mcqj).**

**Seager and her team have also found that nucleic acids, which make up DNA, can withstand the concentrated sulphuric acid. "We're toying with this idea that if there is life, perhaps it uses sulphuric acid as its solvent, and that's just insane," says Seager.**

**We don't know what a sulphuric acid-based life would look like, but amino acids are a good starting point, says Paul Rimmer at the University of Cambridge. "[Perhaps] there are different ways of linking them together in sulphuric acid."**

**While sulphuric acid is a large component of Venus's clouds, they also contain other potentially lethal chemicals, and lack some of the conditions thought necessary for life, says Javier Martin-Torres at the University of Aberdeen, UK. In 2021, for example, Martin-Torres and his colleagues found that the clouds were too dry to plausibly support life as we know it.**

**Alex Wilkins**

Environment

## US hydropower generation set to fall as climate gets drier

Alec Luhn

**HYDROPOWER generation in the western US may fall by as much as 20 per cent by 2050 due to global warming, even as electricity demand increases.**

**Snowy peaks are called the "water towers" of the western US because their meltwater feeds its rivers through the hot summer. But as temperatures rise, leading to less snow and more evaporation, stream flow will decrease across most drainage basins.**

**That could result in up to 20 per cent less electricity generation by dams annually and up to 30 per cent less in the summer, according to a model developed by David Yates at the National Center for Atmospheric Research in Boulder, Colorado, and his colleagues (*Earth's Future*, doi.org/mctm).**

**At the same time, water-related electricity use will increase by up to 4 per cent each year and 6 per cent in the summer, largely because farmers will have to pump more groundwater for irrigation. That is in addition to the higher summer electricity demand for air conditioning already expected.**

**"We see the whole Western Interconnect [power grid] on the electricity side responding to the push or the tension that the water sector will place upon it," says Yates.**

**Currently, the reservoirs behind the Glen Canyon and Hoover dams are barely a third full because cities and farms continue to extract too much water from the Colorado river, a problem compounded by the worst megadrought in 1200 years.**

**The study shows that the shift away from fossil fuels planned by several western US states could be more difficult than anticipated, because the traditional stopgap for falls in hydropower or surges in demand is to use natural gas, says Jordan Kern at North Carolina State University.** ▮

Astrophysics

# The sun could contain a tiny black hole that formed in the big bang

Alex Wilkins

STARS could have tiny black holes hiding inside them that were formed during the big bang. This idea, first dreamed up by Stephen Hawking, might also explain the origins of dark matter, researchers have found.

In 1971, physicist Hawking was looking at a problem involving an apparent lack of high-energy particles coming from the sun. He wondered whether this so-called solar neutrino problem could be solved if the sun hosted a small black hole that formed at the start of the universe, known as a primordial black hole. Some astronomers took the idea further, but when this neutrino problem was solved in a different way in 2001, interest in black hole-hosting stars died out.

Now, Earl Bellinger at the Max Planck Institute for Astrophysics in Germany and his colleagues have revived the idea as a possible explanation for dark matter, and calculated what effects primordial black holes of different masses might have on the evolution of their host star.

**If there is a black hole inside the sun, it would affect our star's activity**

For our sun, Bellinger and his team ruled out black holes with masses smaller than a typical asteroid because these wouldn't grow or have measurable effects. They also ruled out those larger than the sun itself, as these would rapidly eat up their star. This left black holes with about the mass of the planet Mercury or larger, which would accrete matter and grow, but not too quickly (*The Astrophysical Journal*, doi.org/mcpm).

**~500**

**Number of "red stragglers" that may show signs of black holes**

Such a black hole that is sucking up the sun's fuel from the inside would make the star grow by producing powerful light that pushes out its outer layers. This would, over millions of years, cool the temperature below that needed for nuclear fusion, which is the reaction that keeps a star stable, says Bellinger.

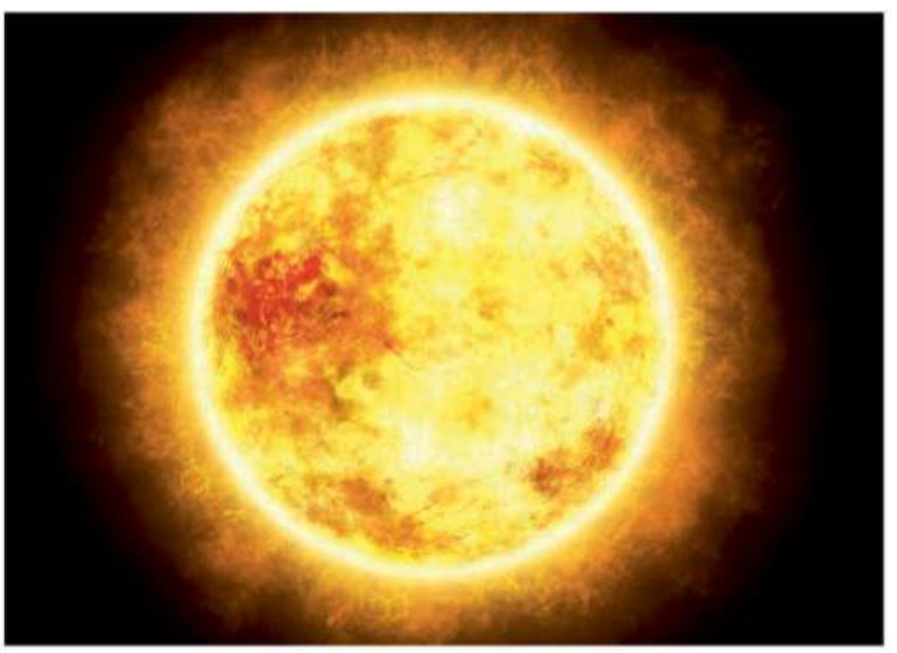
The cooling effect would cause the entire star to become tumultuous and chaotic, like a pot of boiling water. It would ultimately turn into a rare kind of unusually cool star called a red straggler. A black hole at the centre of a red straggler would also make it pulsate in a unique way – a signature that Bellinger hopes to now look for in the 500 or so red stragglers we currently know of.

The fact that black hole-hosting stars would pulse in this way means it is unlikely that our sun is one, because we would have already seen this signature, but it isn't impossible.

A black hole small enough to create a hard-to-spot signature could still affect the sun's evolution, says Bellinger. Such a black hole would lower the sun's temperature, saving Earth from being engulfed by our star when it eventually runs out of fuel and turns into a normal red giant. However, it would still get hot enough to boil off Earth's oceans and kill all life.

If we do find other stars hosting primordial black holes, then they could help explain dark matter, which is what is thought to cause the otherwise unaccounted for gravitational effects we see in the universe, such as galaxies rotating faster than expected based on the influence of visible matter alone. If black holes are hiding in stars, their extra mass could go some way to explaining this effect, says Bellinger.

Although such stars could theoretically explain dark matter, says Paulo Montero-Camacho at Tsinghua University in China, there is a large assumption in the work, which is that stars can grab primordial black holes in the first place. "It's difficult for a star to actually capture primordial black holes, since they are so tiny and move so fast," he says. ▮



NIXX PHOTOGRAPHY/SHUTTERSTOCK

Space flight

# Rocket engine burns itself up for fuel

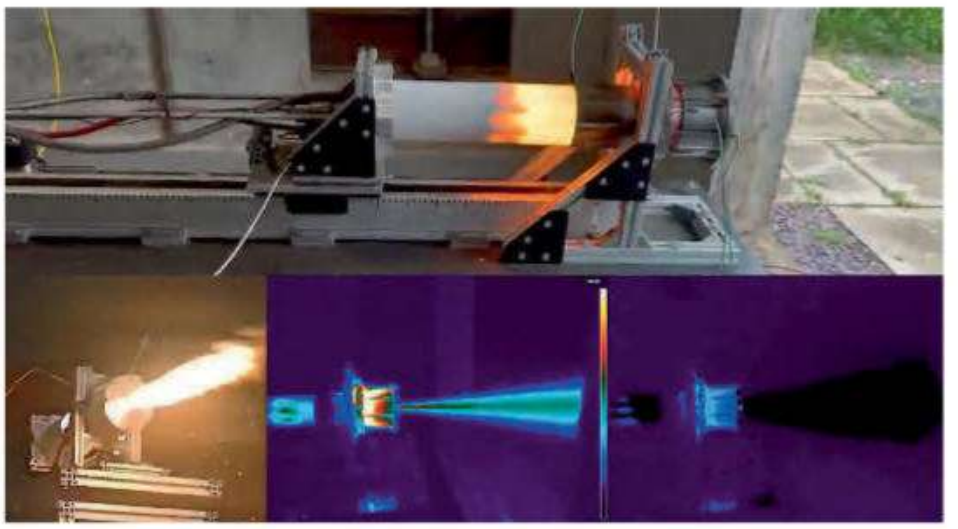
## A prototype rocket uses its own fuselage as propellant to avoid carrying dead weight

**Leah Crane**

ROCKETS that eat themselves may be on the way. To reach orbit, a rocket must hoist its own mass and the mass of its propellant, as well as whatever payload it is carrying. But if a rocket could burn its own parts as fuel, it could free up capacity to transport more crucial cargo. A team of engineers has now built a prototype of one of these "autophage engines".

The concept of a rocket that eats its own parts was first patented in 1938, but a working prototype was never built because it would have been tough to execute with the enormous rockets that have historically performed most launches. In recent years, however, small satellites have risen in popularity, so there is increasing demand for smaller rockets.

Krzysztof Bzdyk at the University of Glasgow, UK, and his colleagues have built a small prototype of a rocket engine that eats its own fuel tank. It isn't powerful enough to loft anything into space, but it successfully demonstrates the concept. The researchers presented their work at the American Institute of Aeronautics and Astronautics SciTech Forum in Florida on 10 January. The engine is called the Ouroborous-3, named after the ancient symbol of a snake eating its own tail.



BZDYK ET AL.

**Krzysztof Bzdyk, Patrick Harkness and Jack Tufft (above) work on the prototype rocket that burns its fuselage (left)**

Like the emblematic snake, the engine is designed to devour its own back end as it uses up the rocket fuel contained there. "As you burn through your propellants, you have these empty tanks where you've got all of this structural mass that's not being useful," says Bzdyk. "So what we're doing is consuming that dead weight so you don't have to carry it with you on the way up, and that allows you to carry more mass to space."

In the prototype, as the oxygen and propane that make up the main fuel are burned, the plastic tube that holds that fuel is also fed into the engine. The tube constitutes up to one-fifth of the total propellant, which provides about 100 newtons of thrust – only about four times as much force as it takes to break an egg.

The team is now working on a larger prototype that could provide about 1000 newtons of thrust – around one-sixth as much as the engine will need to make it to suborbital space and about 1/20th as much as it will require to reach orbit.

"With added tests, they should be able to scale up the rocket... [but] sometimes scaling up is not trivial, easy or likely," says Haym Benaroya at Rutgers University in New Jersey.

Challenges will include making sure the plastic fuselage is fed into the engine and burned at a consistent speed, and testing how burning up pieces of the rocket alters its flight path.

Such engines could help ease the problem of space junk by burning up leftover bits of spacecraft rather than leaving them to hurtle around in orbit and possibly endanger other satellites. ▮

Marine biology

## Some corals change sex each year to boost mating odds

**MANY colonies of hammer coral change sex annually. The pattern seems unique among animals.**

**In 2011, Shinya Shikina at the National Taiwan Ocean University and his colleagues discovered that hammer corals (*Fimbriaphyllia ancora*) in the tropical West Pacific Ocean can change sex. At that time, the only coral group known to change sex was mushroom corals, which are generally solitary and can move around a reef. But *F. ancora* dwells permanently in single-sex colonies containing individuals that are either all male or all female.**

**To learn more, Shikina and his colleagues kept tabs on 26 hammer coral colonies in Taiwan's Nanwan Bay over eight years. Nineteen of the colonies – about 73 per cent – shifted between sexes every year. The other seven colonies remained fixed as either female or male (bioRxiv, doi.org/mchk).**

**The researchers took samples from the sex-changing colonies and looked at their gonads under a microscope. In the months following sperm or egg release, testes tissue wanes before converting into an ovary and vice versa. This is similar to a process that certain sex-changing fish also undergo.**

**There are many types of hermaphroditism. Some animals, like slugs, have functional male and female sexual organs at the same time. Clownfish start as male and can become female. But no other species is known to change sex annually. "This new knowledge expands the sexual plasticity of corals beyond what I was expecting," says Chiara Benvenuto at the University of Salford, UK.**

**Shikina and his colleagues suggest that if there are colonies in a population that alternate between expelling sperm and eggs, it may increase the overall odds of successful mating. ▮**

**Jake Buehler**

**73%**
Proportion of coral colonies switching sex every year

Environment

# Water pipes farmed for electricity

Passing drinking water through mini-turbines can provide huge amounts of renewable energy

James Dinneen

THE excess pressure in water pipes can be used to spin miniature hydroelectric turbines, providing an underutilised source of clean energy. Some envision a network of small turbines serving as a form of reliable storage to back up wind and solar power.

"I think it is a very under-tapped resource," says Shannon Ames at the Low Impact Hydropower Institute, a non-profit organisation based in Massachusetts. "The infrastructure is there. Adding a turbine into the infrastructure makes a lot of sense."

This type of "in-conduit" hydropower already supplies about 530 megawatts of generation capacity in the US, according to a 2022 study by researchers at Oak Ridge National Laboratory in Tennessee. If such systems were installed at all potential sites in the country, the study estimated this could provide at least 1.41 gigawatts of additional capacity – equivalent to around 450 onshore wind turbines – without requiring any large new infrastructure to be built.

"Billions of miles of pressurised pipelines exist in the world," says Gregg Semler at InPipe Energy,

**"It is a very under-tapped resource. Adding a turbine into the infrastructure makes a lot of sense"**

an Oregon-based company that has installed three such systems, including one that powers floodlights in a baseball stadium outside Portland. The company's latest installation to a drinking water pipe for the East Bay Municipal Utilities District (EBMUD) in California started generating power in November.

The EBMUD system is expected to generate 130,000 kilowatt-hours of electricity per year, which will be used to power nearby water pumps. Any excess power will be sent to the grid, helping the district move towards its target of carbon neutrality by 2030, says Christopher Tritto at EBMUD. The project is predicted to reduce EBMUD's carbon dioxide emissions by about 6 tonnes each year.

Semler says a similar system will be installed in Aurora, Colorado, in April, and that InPipe is in discussions with the New York City government. Eventually, he envisions water utilities with networks of small systems working in concert as a form of hydropower storage backing up intermittent renewables.

"If there was no sun or there was no wind, water utilities could put more water through the pipes to produce more energy," he says.

InPipe's system serves the same function as a regular pressure valve, which dissipates the excess water pressure generated by gravity and pumps. Instead of simply releasing this pressure, however, InPipe's technology uses it to generate electricity. In parallel to an existing valve, the system diverts piped water through a bypass, where it spins a hydroelectric turbine before returning it to the pipe. "We don't change the flow of the water, but we take out pressure," says Semler.

Other hydropower companies, such as NLine Energy and Canyon Hydro, have developed similar in-conduit hydropower systems, but only 100 or so have been installed, says Frank Zammataro at Rentricity, a New York City-based company that has installed more than 30 systems across the US.

However, Zammataro thinks such systems could soon be adopted more widely thanks to an emphasis on cutting emissions. ▮

Aeronautics

## NASA unveils X-59 plane to test quiet supersonic flight

**AN EXPERIMENTAL aircraft commissioned by NASA will fly over major US cities at faster than the speed of sound. The X-59 plane is made by Lockheed Martin and was revealed to the public on 12 January. Its purpose is to gather evidence that will determine if supersonic commercial aviation over land should be legalised.**

**Aircraft create shock waves once they pass the speed of sound. This "sonic boom" is so loud it can shatter windows and set off car alarms. When flying at an altitude of 15,000 metres, the boom from the now-retired Concorde would hit a 100-kilometre-wide area below.**

LOCKHEED MARTIN

The X-59 aircraft was revealed in Palmdale, California

**There are currently restrictions on supersonic flight over land, but the X-59 may be the start of that changing. NASA developed the X-59 as part of its Quiet Supersonic Technology (Quesst) project, which aims to investigate ways to minimise sonic booms. It plans to fly the aircraft over major US cities at 1510 kilometres per hour and then survey residents about the experience.**

**No date has been set for the first flight yet. Cathy Bahm, who manages the project at NASA, says there is only one X-59 aircraft and testing will therefore be thorough. "When it takes off, I'll be holding my breath until it lands," she says.**

**Bahm hopes the project will prove that regulations can be changed to allow overland supersonic flight. "We think that it'll more blend into the background of everyday life than the Concorde did," she says.**

**If the X-59 proves a success, Bahm is confident it could show designers of large commercial aircraft how to achieve the same thing at scale in future.**

**"I believe that there will be parts of the X-59, essentially the DNA of X-59, incorporated into those aircraft: the long nose, the engine over the wings, the smooth surface under the aircraft. I think those are all key for the lower noise signature," says Bahm.** ▮

**Matthew Sparkes**

Technology

## Weibo fails to curb abuse by showing users' locations

Chris Stokel-Walker

**A CHINESE social network's attempt to reduce abuse by displaying people's estimated locations alongside their posts actually gave fellow users a new weapon with which to sling insults.**

**In April 2022, Weibo, the closest Chinese equivalent to X (formerly Twitter), began to display the province or municipality where someone is based according to their internet protocol (IP) address – a policy designed to reduce incivility.**

**To measure the impact of the change, Tian Yang at the Chinese University of Hong Kong and his colleagues compiled a list of 96 uncivil or abusive words in Chinese. Then they checked how frequently these words appeared in posts replying to 66 notable media profiles on Weibo for 12.5 days before and 12.5 days after the policy change.**

**The likelihood of abuse referring to users' locations increased by 33.5 per cent after the policy change (*New Media & Society*, doi.org/mcfj). The lesson learned is simple, says Yang: "We cannot assume that technology will function in a way that you assume."**

**But he adds that the analysis only looked at one type of uncivil conversation, and displaying IP locations could have had more positive effects in other ways.**

**"There's no silver bullet to fixing online abuse," says Liam McLoughlin at the University of Liverpool, UK. McLoughlin's own research suggests that localised platforms, such as Facebook groups for neighbourhoods, increase the potential for online hate to translate into offline harm.**

**We need to ask different questions, he says. "We have an idea of what types of communication we want to avoid, but we first haven't figured out what types of conversation we actually want."** ▮

Life

# California frog reintroduction is a rare win against deadly fungus

James Dinneen

ROLAND KNAPP

**Mountain yellow-legged frogs in Yosemite National Park, California**

WILD populations of frogs in California seem to have evolved resistance to a lethal skin-eating fungal pathogen. Moving resistant frogs to habitats where the fungus has killed all the others appears to be an effective way to restore populations.

The chytrid fungus *Batrachochytrium dendrobatidis* (Bd) has decimated the populations of amphibian species around the world and contributed to the extinction of many. It infects the skin and ultimately causes heart failure.

Conservationists have tried many methods to protect amphibians, including vaccinating them and altering their microbiomes, with mixed results.

Roland Knapp at the University of California, Santa Barbara, and his colleagues have instead focused on the potential for the two species of mountain yellow-legged frog (*Rana muscosa* and *Rana sierrae*) in California to evolve natural resistance to the fungus.

Although Bd has spread in other parts of the world since the early 20th century, the mountain yellow-legged frogs of California's Sierra Nevada were spared from the fungus until the middle of the century. Instead, most of their now critically endangered populations were killed by trout introduced in the late 19th century.

Knapp and his colleagues were working on getting rid of the trout to restore the frogs

**"For so long, it looked just like gloom and doom and just losing one population after another"**

in Yosemite National Park in California when the fungus began tearing through frog populations, driving them down to less than 10 per cent of their historical range. "It was a horrible rollercoaster," he says.

The researchers were forced to rethink their restoration efforts: if frogs bred in captivity were introduced to areas cleared of trout, they would be killed by the fungus.

So they began moving frogs from wild populations that appeared to be resistant to the fungus to areas where all the frogs had been lost. Over 15 years, starting in 2006, they moved hundreds of the temperature-sensitive frogs – sometimes by helicopter, sometimes in snow-filled backpacks – between cold mountain lakes.

The researchers compared the genomes of frogs from resistant populations with those of frogs that hadn't been exposed to Bd. They found the resistant frogs differed in several genes associated with the immune system, suggesting the source of their resistance was evolved, rather than acquired immunity or some feature of their habitats, says Knapp. It also hinted that resistance could be inherited.

Nine of the 12 sites where the researchers reintroduced frogs now have reproducing populations. Their ecological modelling also suggests that in half of the sites the populations are robust enough to have a greater-than-not chance of survival for at least the next 50 years (bioRxiv, doi.org/mcfb). The researchers are now starting similar efforts in other national parks in California.

"For so long, it looked just like gloom and doom and just losing one population after another," says Cori Richards-Zawacki at the University of Pittsburgh in Pennsylvania. "They have a really convincing line of evidence that that wasn't the end of the story."

Other species have started showing signs of resisting the pathogen and this approach might work for them, says Richards-Zawacki. ▮

Genetics

# Multiple sclerosis as a protector?

The same genes that cause multiple sclerosis may have prevented nomadic herders from catching infections from their animals, finds **Clare Wilson**

THE largest genetic database of ancient humans yet is shedding new light on some modern medical conditions, such as multiple sclerosis (MS), as well as why there is variation among people when it comes to other heritable traits, such as height.

One of the findings is that the genes behind MS may have become more common because they helped people resist infections passed to them from other animals.

Other insights from the study include explanations for why Alzheimer's disease is more common in some groups than in others and why people from northern Europe tend to be taller than those from the south of the continent.

"Things going on thousands of years ago can have really profound effects on the health and longevity of people living in the present," says Evan Irving-Pease at the University of Copenhagen in Denmark.

## Waves of migration

The genes of people with ancestry from Europe and west Asia have been shaped by three large waves of migration. Modern humans living a hunter-gatherer lifestyle first arrived in these regions about 45,000 years ago. There was then a wave of farmers from the Middle East about 11,000 years ago, followed by a further influx, this time of livestock herders from the Eurasian steppe, now called the Yamnaya people.

To understand how these mass movements shaped modern medical conditions, Irving-Pease and his colleagues have been analysing bone and teeth samples from nearly 5000 ancient remains found in museum collections in Europe and west Asia, with the oldest dating back 34,000 years.

The latest research reports on the first batch of samples to be analysed, based on about 1600 individuals. The researchers compared the data for these individuals with modern genetic data from 410,000 people from a huge medical dataset called UK Biobank, analysing only white participants in order to select those with European ancestry.

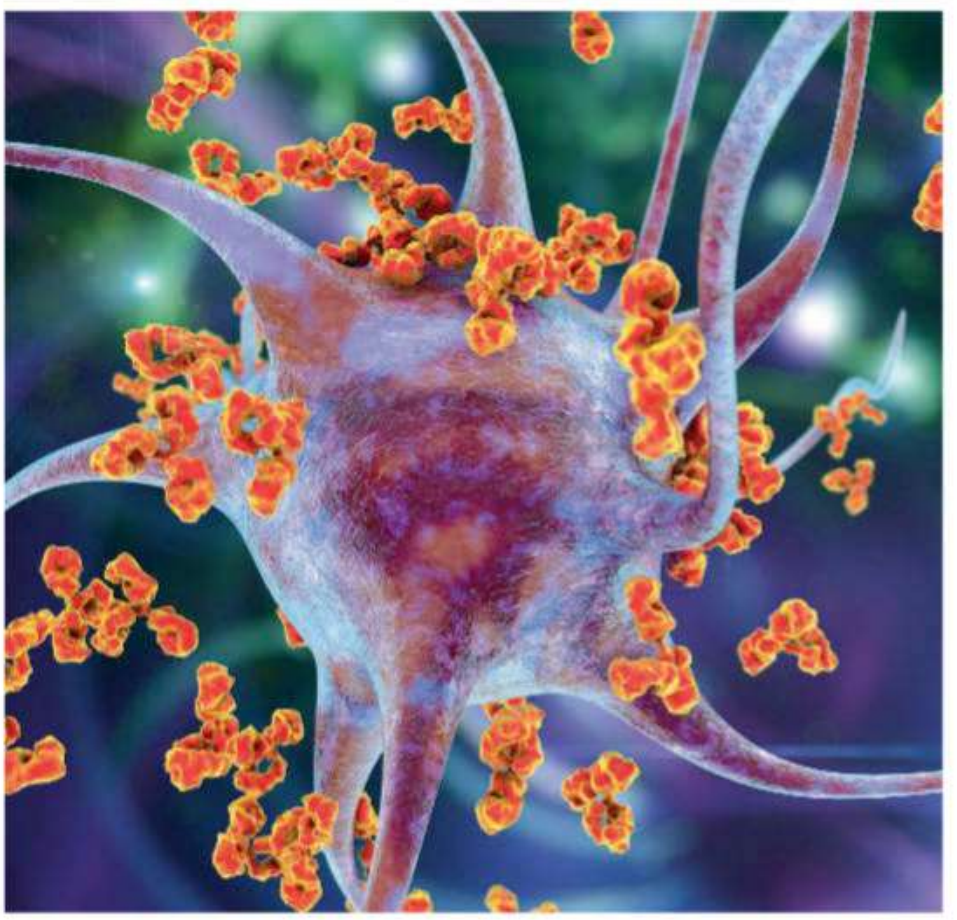
**"Things going on thousands of years ago can have profound effects on the health of living people"**

Irving-Pease and his colleagues started by focusing on MS, an autoimmune condition that occurs when the immune system starts attacking nerves, often leading to progressive disability. Previous studies have found 233 genetic variants that are linked to a higher risk of MS.

Among modern people in the UK, those with a higher genetic risk of MS have more ancestry from the Yamnaya, the results show. The team also found that some of these MS-predisposing genetic variants first arose in the Yamnaya and became more frequent in their descendants as they spread west through Europe.

Given that some of the 233 variants that are linked to MS also affect the immune system, coupled with the Yamnaya having lived among animals, the researchers concluded that the genes behind MS probably helped the Yamnaya fend off bacteria and viruses that can spread to people from animals (*Nature*, doi.org/mcdx).

The team has also previously shown that a few of the MS risk variants are linked with partial resistance to tuberculosis.



KATERYNA KON/SCIENCE PHOTO LIBRARY

**Multiple sclerosis occurs when the immune system starts attacking nerves**

In another paper, the researchers have shed light on how our ancestry affects our genetic risk for Alzheimer's disease. People today are more likely to have a gene called *ApoE4*, which leads to a higher risk of developing Alzheimer's, if they have more ancestry from the first hunter-gatherer populations of Europe (*Nature*, doi.org/mcd8).

## Looking back in time

An alternative variant of this gene called *ApoE2*, which results in a lower risk of Alzheimer's, seems to have arisen in the incoming Yamnaya people, perhaps because it gave protection against malaria or an unknown viral infection, the researchers write in their paper.

The Alzheimer's-protecting variant doesn't give a reproductive advantage, so it wouldn't have been selected for by evolution for its effects on dementia, given that the condition generally occurs long after people would have had any children, says Benjamin Trumble at Arizona State University, who wasn't involved in any of the research.

"The cool thing about this paper is they're looking back deeper into time and they're saying what may have been advantageous or disadvantageous then," says Trumble.

"Too often, we focus on modern environments and we say [a certain gene] is purely deleterious. We have to think about what the selective pressures were at various points in time," he says.

A further finding from the analysis is that among people living in Europe, those with more Yamnaya ancestry tend to be taller, which may explain why people in northern Europe – who often have more Yamnaya genes – are taller on average than those in the south.

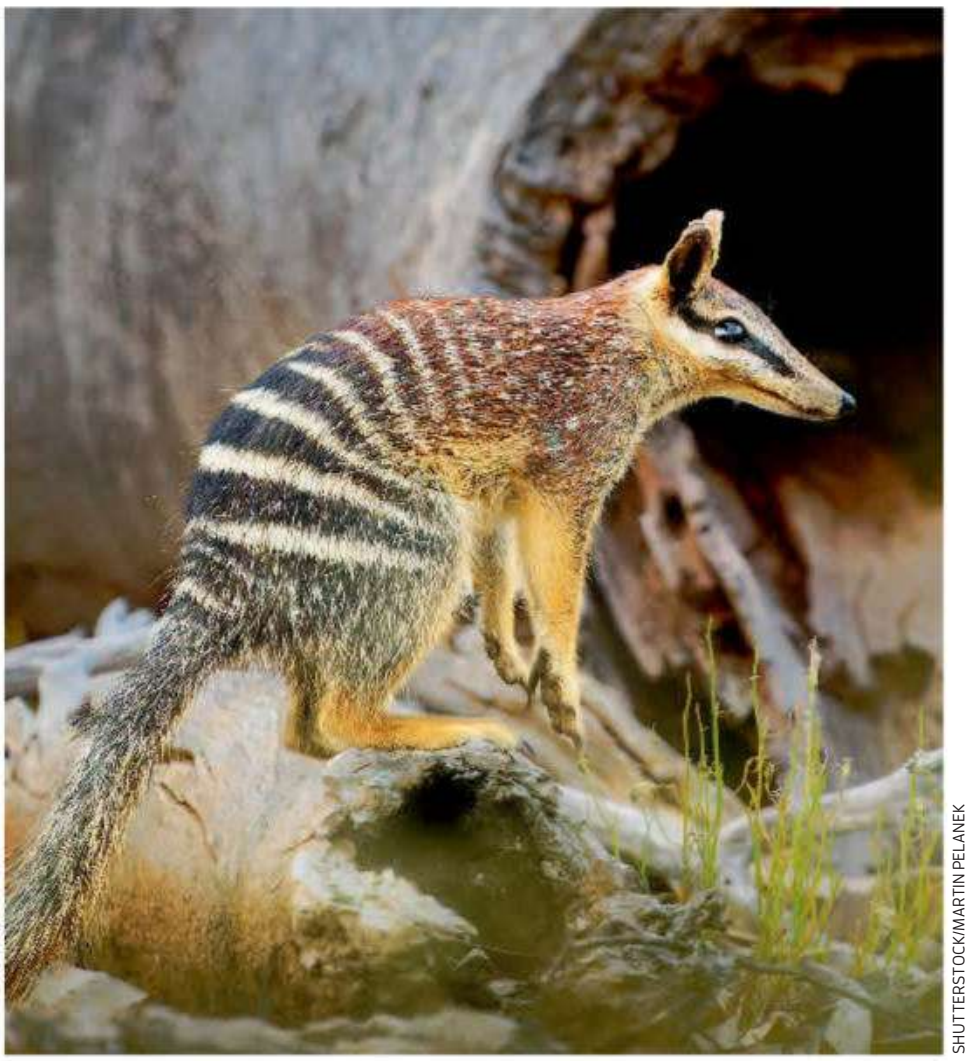
Astronomy

## Origin of weird radio burst found

A MYSTERIOUS flash of radio waves that hit Earth in 2022 came from a small group of galaxies some 8 billion light years away.

To date, we have spotted more than 1000 strange pulses of electromagnetic radiation like this, known as fast radio bursts (FRBs). A leading explanation is that they are generated by rotating stars known as magnetars. In 2022, astronomers found the most distant and powerful one yet: FRB 20220610A.

We now know this came from a small dwarf galaxy that is part of a compact group of seven galaxies about 8 billion light years away, Alexa Gordon at Northwestern University in Illinois and her team told a recent meeting of the American Astronomical Society in New Orleans, Louisiana. **Jonathan O'Callaghan**



SHUTTERSTOCK/MARTIN PELANEK

Palaeontology

## Fossilised skin is oldest known

FRAGMENTS of fossil skin are the most ancient we have found so far and could help us understand how skin evolved.

It is rare for this part of a body to be preserved because it decays quickly. But one Palaeozoic reptile fell into oily clay sediment in what is now Oklahoma, which slowed the decay process long enough for the tissue to fossilise.

Tea Maho at the University of Toronto in Canada and her colleagues spotted scales in black fossil fragments from 300 million years ago. Based on nearby fossils, they suspect that the skin came from *Captorhinus aguti,* a lizard-like species (*Current Biology*, doi.org/mcg9). The fossil is 21 million years older than any skin found before, illuminating the evolution of this tissue in vertebrates following their shift from the sea to land. **Corryn Wetzel**

Life

## Numbats are overheating as Australia gets warmer

**THE fur that numbats evolved to conserve energy is now putting them at risk of overheating in Australia's increasingly hot temperatures.**

**Numbats (*Myrmecobius fasciatus*, pictured above) are marsupials that are active during the day, eating termites hidden under logs and soil. Since these insects are a low-calorie meal, numbats – which typically weigh about 500 grams – have evolved fur that absorbs heat from the sun, saving calories that would otherwise go towards generating body heat.**

**As temperatures rise, that evolutionary trait seems to be backfiring, says Christine Cooper at Curtin University in Perth, Australia.**

**To learn more, Cooper and her colleague, Philip Withers at the University of Western Australia, used a thermographic camera to film 50 wild numbats as they fed on termites in 2020 and 2021.**

**At each site, they recorded factors such as air temperature, wind speed and humidity. They then used a computer model to assess how environmental conditions affect numbats' internal temperatures.**

**The pair found that on days of high heat stress – for example, a dry environment with 40°C (104°F) air temperature – numbats overheat within 10 minutes of being in direct sunlight (*Journal of Experimental Biology*, doi.org/mcg5). They then need to stop feeding and hide from the sun until their body temperature drops.**

**To help the animals overcome these problems, Cooper recommends conservation groups relocate numbats to relatively cooler areas within their territory and ensure there is sufficient shade. Christa Lesté-Lasserre**

## *Really* brief

SHUTTERSTOCK/NIKSDOPE

### Office well-being schemes are flops

**The well-being initiatives offered by many firms made no difference to the mental health of employees, according to a survey of more than 46,000 workers at 233 organisations. The result was consistent across different sectors (*Industrial Relations Journal*, doi.org/mchc).**

### Diamond rain may fall on many planets

**Compressed carbon compounds can turn into diamonds at less extreme temperatures than theorised, which means diamond rain is possible on smaller planets than we thought. Of the 5600 or so spotted exoplanets, more than 1900 could have such precipitation (*Nature Astronomy*, doi.org/mchd).**

### There's nothing like a Guinness yeast

**Strains of *Saccharomyces cerevisiae* yeast used to create the drink Guinness are different enough genetically from other Irish brewing yeasts to belong to their own subpopulation. Guinness strains create a buttery taste and a clove-like aroma (*Communications Biology*, doi.org/mchf).**

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# Views


**The columnist**
**Graham Lawton** on the push to turn fish waste into gold p22

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Enter the wonderful world of the cave manatees p24

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Ditch the car and take a wheeled shopping trolley instead p26

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Try a mind-bending history of multiverse thinking p28

**Culture columnist**
**Emily Wilson** delves into a provocative tale of a trans Jesus p30


Comment

# A dying shame

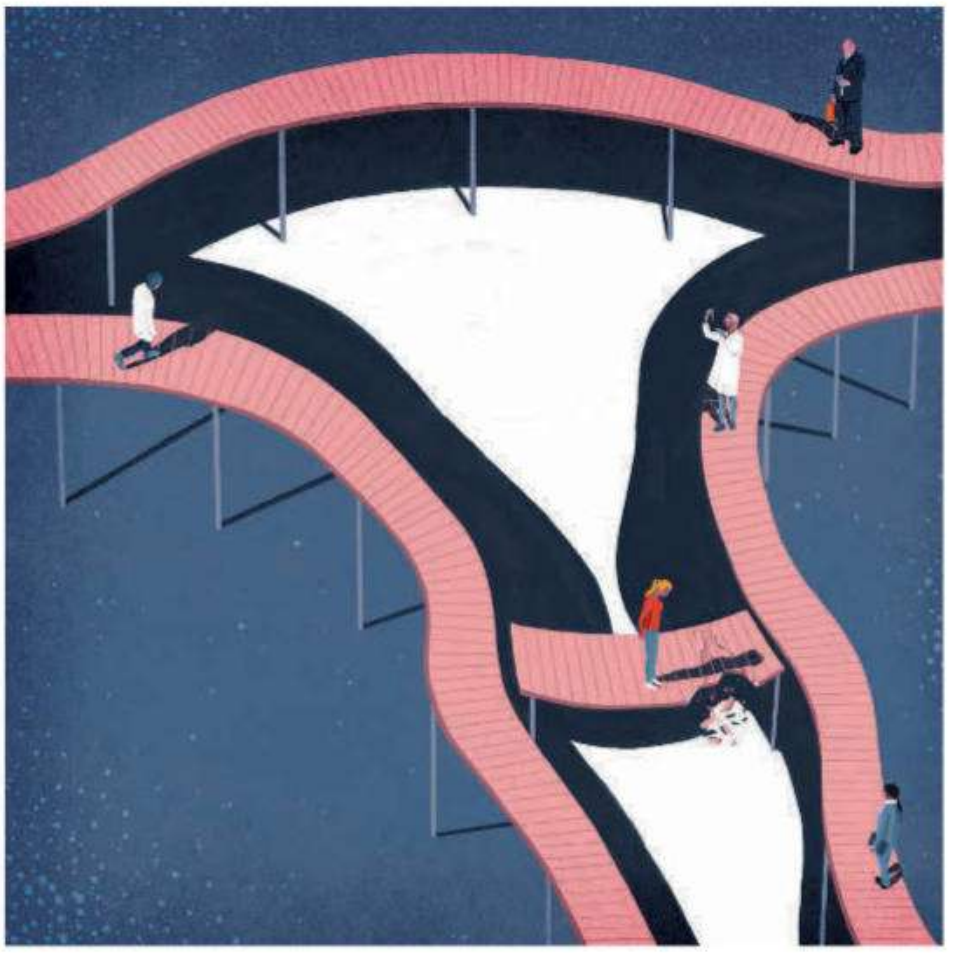
Twenty years after we developed a cervical cancer vaccine, the disease is still killing. Politics and economics got in the way, says **Linda Eckert**

IN 2003, those of us deeply involved in the prevention of cervical cancer heard some astonishing news. Results of a four-year, placebo-controlled trial of a prototype vaccine for a form of the virus that causes this cancer, known as HPV-16, were out. Of the 2400 participants who had the active vaccine, not one acquired an HPV-16 infection. Not one. Twelve years into my career as an obstetrician-gynaecologist, I knew I was witnessing a miracle.

Today, 20 years later, this cancer continues to kill – one woman every 2 minutes – and cases are on the rise: 604,000 in 2020, projected to reach 855,000 by 2040. That means millions of deaths and disfigurement and the forfeit of sexuality and fertility for survivors. It is scandalous.

It is also proof that, as much as I would love it to be otherwise, science is never enough. Its discoveries actually change the world only when they overcome political, economic and cultural challenges. We, the researchers so eager to launch extraordinary discoveries into the world, must understand, participate in and prepare for that.

Every vaccine that leaves the laboratory enters a world of supply and demand, where the market's loyalty to the highest bidder allows places like the US, which can pay $160 per HPV vaccine dose, to purchase all the supply they need. The lowest-income countries rely on subsidy from the global health body Gavi (which negotiates a $4.55/dose price) and get their doses after the demands of higher-income countries have been met. In 2018, a global HPV vaccine shortage – in no small part because, until recently, most of the world's supply was manufactured by just one company – left 34 million girls unvaccinated in countries where cervical cancer screening and treatment are as impossible to finance as the jabs. And for the "caught-in-the-middle" countries – too "rich" to receive vaccine subsidy, but not rich enough to buy it – the market is a long way from allowing them any access at all. This isn't about science. This is economics, public policy and resource sharing, things that we, as scientists, had better care about if we want our work to actually do the work.



SIMONE ROTELLA

Another obstacle to the HPV jab's world-changing potential is infrastructure and delivery. Traditional programmes immunise very young children, but the vaccine's target population is 9 to 14 years old. Adding an entirely new entry to a country's list of vaccines demands storage, scheduling, training and other logistical changes. Again, not science, but integral to moving such medical research out of the laboratory and into the arms of the people for whom it was created.

However, the most intractable challenges to the vaccine's promise to prevent cervical cancer spring from the fact that its primary audience is girls and its chief target a sexually-transmitted disease. It butts up against cultural fears, stigmas and inequities in low, middle and high-resource settings alike. The notion that the vaccine will encourage promiscuity in girls, though thoroughly disproven, persists. Claims about side effects, despite being swiftly investigated and dispelled, brought Japan's astonishing 70 per cent vaccination rate to near zero for a decade. Since the covid-19 pandemic, most of us know painfully well that science alone is helpless in the face of misinformation and requires muscular public health messaging and robust trust.

In 2003, I thought we might see the elimination of a cancer in my lifetime. Today, just 1 in 5 girls eligible for the HPV vaccine have received it. I have come to see that the research on its own isn't enough. Unleashing the world-changing power of this vaccine requires us to deal with politics, economics and culture too. ▮

Dr Linda Eckert is the author of *Enough: Because we can stop cervical cancer*

No planet B

# **Would you like that in cod skin?** A project in Iceland is setting out to use every part of caught fish, including repurposing waste fish skin to make leather and skin grafts, finds **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

## Graham's week

**What I'm reading**
Julia *by Sandra Newman, a retelling of George Orwell's* Nineteen Eighty-Four *from the perspective of Winston Smith's lover.*

**What I'm watching**
*The second series of* The Traitors *on the BBC.*

**What I'm working on**
*A reporting trip to the remote Pitcairn Islands.*

This column appears monthly. Up next week: Annalee Newitz

AFTER taking a breather for a couple of months, I am back onto two of my favourite subjects: fish and the Nordic countries. I used to be jokingly known as *New Scientist*'s ambassador to Finland. I have now switched my allegiances to Iceland after two reporting trips there last year.

One was to cover the horrors of the open-pen salmon farming industry. The other was to visit the country's leading innovators in the green economy, including a company with an audacious plan to drill into a magma chamber to tap it for energy.

Less spectacular, but perhaps equally consequential, is a project called 100% Fish, the brainchild of entrepreneur Thor Sigfusson. He is the founder and chairman of the Iceland Ocean Cluster in Reykjavík, which is an incubator for "blue economy" companies attempting to turn a profit from material that is currently discarded as waste.

There is a lot to work with, especially in the fishing industry. Consider cod, which still live in relative abundance in the North Atlantic. Icelandic boats sustainably land some 60 million of them a year, says Sigfusson; about 40 per cent of the catch is used for food. The other 60 per cent – skin, bones, fins, internal organs and heads – is usually thrown away. Or it used to be.

The same is true for wild-caught fish the world over. This adds up to 10 million to 15 million tonnes of fish waste a year, which largely goes to landfill, says Sigfusson. "People say this is waste," he says. "We are saying there is no waste in the fishing industry. Our mission is to utilise all parts of the fish."

Some fishy by-products, such as milt (seminal fluid), roe and cod liver oil, have long been widely used for food and supplements. But others are newcomers.

We gather round a large table groaning with innovative products made from fish waste. The most striking are the leather goods – purses, slippers and bags – made from the skin of the spotted wolffish. It is a stunning product, tough and flexible like ordinary leather but much more eye-catching: silvery smooth with dark brown blotches. The skin of other fish, including cod and salmon, can also be processed to make leather. Weight for weight, it sells for the same price as prime fish fillet.

**"Leather made from the skin of the spotted wolffish is a stunning product, tough, flexible and eye-catching"**

Fish skin also supplies the protein collagen, a valuable commodity for food supplements. "It's good for the joints, it's good for the skin," says Sigfusson. The collagen also goes into a health drink called Collab, one of the most popular in Iceland. Calcium from the bones can also be utilised.

There are also fish-waste cosmetics, pharmaceuticals, supplements and snacks, as well as a rather menacing desiccated cod's head. These fish heads are dried using geothermal heat and exported to Nigeria to make soup. There isn't a single scale or drop of oil that can't be used in some way. Even the eyeballs can be drained for useful compounds.

Right now, Iceland turns about 85 per cent of its fish waste into value-added products. A few fishers in remote regions have yet to take the bait, but it is only a matter of time. "We're trying to reach 100 per cent," says Sigfusson.

The jewel in the crown is a product invented by biotech company Kerecis, based in Ísafjörður, a fishing town in the far north-west. It uses fresh, intact cod skin as a graft to heal stubborn burns, wounds and ulcers. The product replaces standard skin substitutes made from human and pig tissue, which have to be treated with harsh anti-viral compounds to eliminate the risk of passing infections on to the recipient. Cod and humans don't share any viruses, so Kerecis has eliminated that step, saving money and creating a more natural product. In 2014, Kerecis received approval from the US Food and Drug Administration for its technology and, in 2022, made a profit for the first time.

"This is saving lives," says Sigfusson. It is also making serious money. A single cod-skin graft can sell for $2700. When Kerecis founder Fertram Sigurjonsson approached the Iceland Ocean Cluster a decade ago, he asked for $1 million in initial investment. In August 2023, the Danish medical products company Coloplast bought Kerecis for $1.3 billion.

As a result of these innovations, fish is even more valuable than before. The flesh from a 5-kilogram cod fetches up to $50. Add in the co-products and that rises to $500. With Kerecis, it tops $5000 per fish, with no waste whatsoever.

Other fisheries are catching on. The Ocean Cluster project has offshoots in the US, Denmark and Namibia. In the US and Canada, 18 companies have signed up to the 100% Great Lakes Fish pledge, which aims to use every bit of the catch there by 2025. "It makes sense because it's value for the industry and value for the coastal communities," says Sigfusson. There's gold in them there gills. ▮

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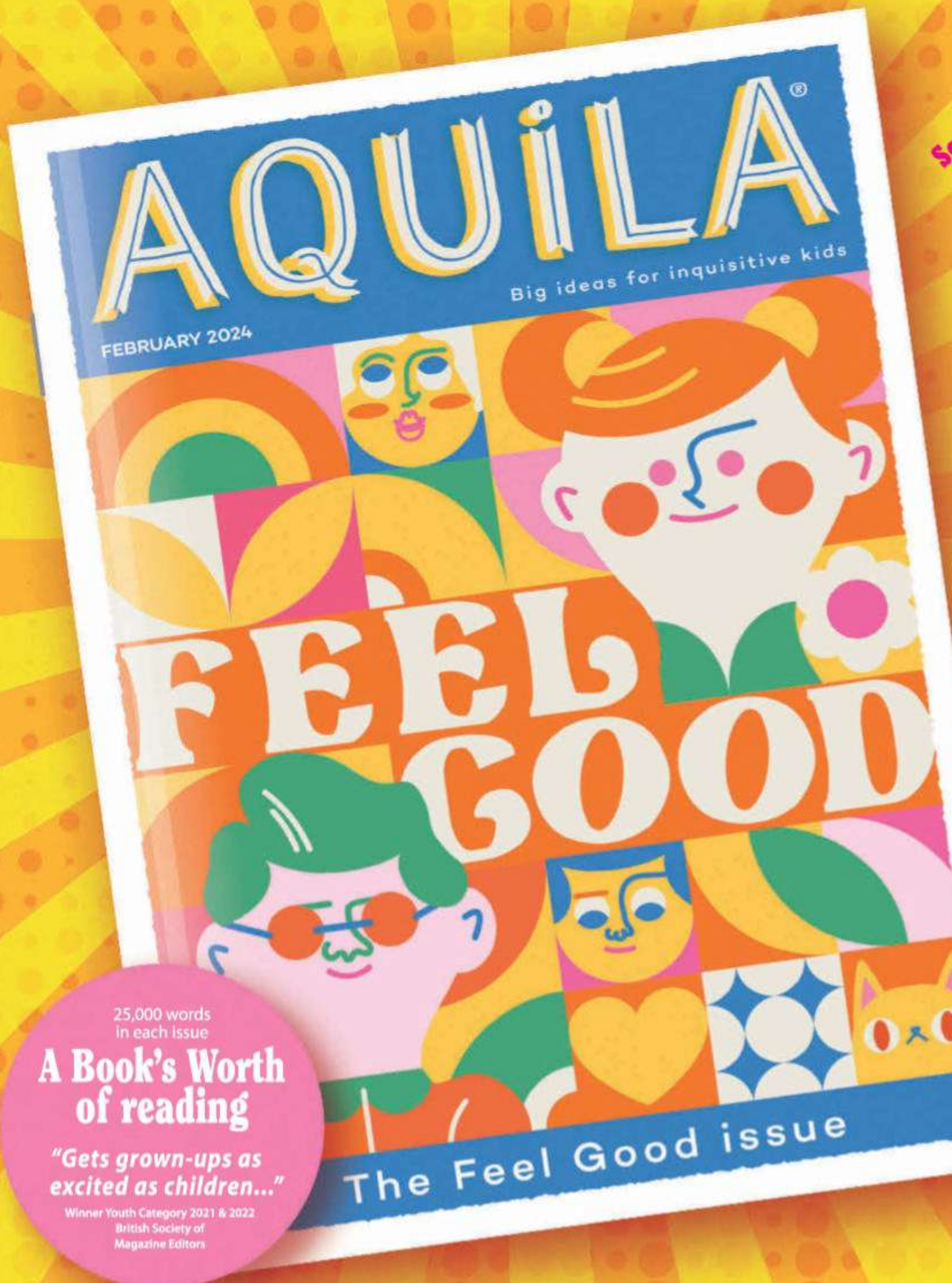


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# Manatee magic

**Photographer Klaus Thymann**

IN A flooded cave system in the Mexican state of Quintana Roo, on the Yucatán peninsula, a manatee mother (far left) swims up to cave diver Klaus Thymann, who captured stunning images of these endangered mammals living in a unique, under-explored habitat. "Of course, I think she's looking at me," says Thymann. "But the reality is she's probably looking at the reflection in the camera."

Carved into limestone rock by flowing water, the cave system, thought to be up to 16,000 kilometres long, links the coast with inland cenotes, freshwater-filled sinkholes created when cave roofs collapse. Thymann and his fellow divers have been exploring this system (left, bottom) to film manatees, which, unlike the humans, navigate the passages with ease.

The manatees have probably been in the region for generations, says Thymann, yet there are estimated to be fewer than 250 of them in the Mexican Caribbean. Thymann is concerned that construction projects nearby are putting the area's aquatic species at risk. A new train line will bring even more development to the popular tourist destination (left, top). Construction can block the flow of water in the system, starving it of oxygen and potentially trapping manatees. Wastewater from surface run-off and sewage systems lowers the water quality in the area's aquifer.

Though the coastal area is a protected manatee sanctuary, this doesn't extend inland, where these manatees were photographed. So, while finding manatees within a relatively untouched cave network is positive news, these habitats may not remain so pristine for much longer.

**David Stock**

## Editor's pick

### Trolley dilemma: Will you use one to save the planet?

**Letters, 30 December 2023**
*From Tess Harris, London, UK*
**Recent correspondence has focused on transport options, such as encouraging more walking, free local buses and so on, as ways to cut car use. To this end, I would like to propose that every UK household is given a shopping trolley.**

**My trolley has been a companion since 1991, bought in Paris where everyone had one. Aside from carrying store goods and saving on backache from lugging heavy bags, it has also transported compost and plants from the garden centre, tiles from the local store, rubbish to the recycling dump and parcels to and from collection points. Despite a wobble, it remains stylishly French and supremely useful.**

### AIs may develop a language of their own

**30 December 2023, p 19**
*From Donald Windsor, Norwich, New York, US*
Philip Seargeant discusses the implications of artificial intelligence making it easier to communicate by bridging the gap between speakers of various languages. However, AI might create its own language to communicate with other AIs all over the world and humans won't be able to understand what they are talking about.

### Mesoamericans perfected this food-bridging recipe

**16/23 December 2023, p 70**
*From Tony Power, Sydney, Australia*
Stuart Farrimond, in his look at the science of "food bridging", seems to have rediscovered the classic Mayan/Aztec dish turkey mole, also familiar as the variant "chocolate chicken". The peanut bridging ingredient originated in Central America before becoming more widely known.

### Proof of cosmic life may be lurking in your kitchen

**16/23 December 2023, p 64**
*From Geoff Harding, Sydney, Australia*
The survivability of bacteria under extreme conditions, as highlighted in "What's living in your kitchen?", surely gives support to the theory of panspermia. This proposes that life such as bacteria may travel the universe via a suitable object and seed hospitable planets.

Perhaps bacteria can't survive in a vacuum, but could be trapped within meteors or comets for millennia or even millions of years. Detection of exotic bacteria in rocks from space would offer the simplest proof that life is widespread in the universe.

### A ready source of wrecks to protect marine parks

**9 December 2023, p 13**
*From William Hughes-Games, Waipara, New Zealand*
You note that shipwrecks not only provide refuges for fish, but foil bottom trawling. A good place to put wrecks would be in protected marine reserves. A good source of wrecks would be boats caught fishing in such reserves.

### Planets' lucky escapes may have simpler explanation

**16/23 December 2023, p 60**
*From Jim McHardy, Clydebank, West Dunbartonshire, UK*
Regarding detection of planets that seem to have survived the death of their star, there seems to be an assumption that a planet in orbit close to a white dwarf was always in that orbit.

Consider a planet that was far out prior to star death. When the dying star ends its red giant phase, shrinking back to form a white dwarf, friction with the ejected stellar nebula could slow the planet, causing it to very slowly spiral inwards. Outer planets could also have their orbits disrupted by close approaches of other stars or other planets. Collisions with moons could do the same.

### Energy efficiency gains can have downsides

**9 December 2023, p 8**
*From Andrew Bodey, Oxford, UK*
Doubling energy efficiency is a headline target from COP28, but is this a win for the planet or for the fossil fuel industry? If not coupled to reductions in fossil fuel production, rebound effects can diminish the emissions reductions that we would expect.

Energy efficiency can even boost overall energy consumption (via an effect known as Jevon's paradox) if, for example, financial savings are reinvested in expansion of carbon-intensive industry. The primary value of improving efficiency is in making a fossil fuel phase-out more practicable. The phase-out is, inconveniently, essential.

### 100 trillion synapses can't be wrong

**Letters, 16/23 December 2023**
*From Anne Barnfield, London, Ontario, Canada*
The saying about the brain being the most complex known structure in the universe is usually stated in relation to its structure, connectivity and circuitry – the connectome.

Consider this: a human brain has about 100 billion neurons. Protuberances from a neuron make many connections with other neurons. The intricate structure gives rise to an estimated 100 trillion connections in the brain. With 100 billion neurons making 100 trillion connections, the human brain is truly complex.

### Let's turn the tables on Western collapse

**9 December 2023, p 36**
*From Ed Shields, Neebing, Ontario, Canada*
Peter Turchin's studies of social collapse may have relevance to the objectives and means of Russia and other states to enhance the collapse of some Western societies. Can't the West use history to expedite the fall of dangerous authoritarian regimes?

### Would a robot world have a biosignature?

**25 November 2023, p 40**
*From Charles Joynson, Rayleigh, Essex, UK*
In searching for extraterrestrial life, we need to think about what we mean by life. It could be organic, based on carbon, hydrogen, oxygen, nitrogen, phosphorus and sulphur. Or it could be completely different. For example, we can imagine machines becoming a second form of life on Earth, capable of Darwinian evolution. How would we detect a planet populated by machines or by organisms using a different chemistry?

### Got that shrinking feeling about BMI

**2 December 2023, p 12**
*From Mark Pearcy, Brisbane, Australia*
Has anyone taken the following into account in describing a "healthy BMI" for older people? We all lose height as we get older, through vertebral body collapse and loss of hydration of the intervertebral discs. Hence, even if our weight stays the same, our BMI will gradually creep up. ▮

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# Inside the real multiverse

There is a lot to learn about the physics of multiverses from a great new guide. Take note, makers of science-fiction blockbusters, says **Bethan Ackerley**

ESCHCOLLECTION/GETTY IMAGES

**Book**

**The Allure of the Multiverse**
**Paul Halpern**
**Basic Books**
**(US, out now; UK, 8 February)**

IN THE battle for the public imagination, the multiverse reigns supreme. Fuelled by the Marvel Cinematic Universe and other franchises, the idea that an infinite number of universes might exist alongside ours (and may even be contactable) has never been so popular. Why do we find this concept endlessly fascinating? And how promising is multiverse science?

Paul Halpern, a professor of physics at Saint Joseph's University, Pennsylvania, tackles these questions in *The Allure of the Multiverse: Extra dimensions, other worlds, and parallel universes*. In it, he explains how and why the multiverse came to be taken seriously in some quarters.

He also corrects a wealth of misconceptions, chief among which is the notion that there is just one way of thinking about the multiverse. Perhaps fittingly, rather than adherents having settled on one story, they are divided among many possibilities – none of which quite resembles the dimension-hopping antics seen on screen.

These options include the many-worlds interpretation, in which all possible outcomes of a quantum measurement are realised in some universe, and eternal inflation, in which the universe's expansion continues forever in some regions, leading to a multiverse. What's more, these multiverse ideas are an island of misfit toys in a sea of more mainstream physics.

The idea of parallel, unreachable worlds stretches back all the way to the ancient Greeks. Under the Pythagorean view of cosmology, Earth was thought to orbit a "Central Fire" that obscured humanity's view of a "Counter-Earth" on the other side. More recently, the 19th-century socialist Louis-Auguste Blanqui argued in his treatise *Eternity Through the Stars* that, in a universe of unlimited size but with a finite number of elements, identical and near-identical Earths were bound to exist somewhere.

**"The idea of parallel, unreachable worlds stretches back all the way to the ancient Greeks"**

Modern formulations have sprung up in the past century. Halpern reveals how multiverses have emerged as potential solutions to the biggest questions in physics, such as the hunt for a theory of everything.

Take the observer effect. In quantum mechanics, a wave function represents the many possible states of a given particle. When that particle is measured by an observer, the wave function collapses into a single state, which is the reality that the observer experiences.

Yet what constitutes an observer remains debated, with detractors seeing this as a fundamental flaw in the concept. Some feel that the branching universes of the many-worlds interpretation solve this issue: here, copies of the observer experience each possible outcome, all encompassed by a universal wave function that never collapses.

It might seem surprising to find eminent physicists on both sides of this debate, but Halpern links this fissure to a wider question: should scientists focus on observable, verifiable pursuits or seek out that which is invisible – for now?

His own view is "cautiously open-minded": he doesn't rule out a possible multiverse, but argues that there "needs to be a strong explanatory benefit that overcomes the stark disadvantage of a lack of direct detectability" if such notions are to be taken seriously.

**Fittingly, science has many ways of thinking about multiverses**

*The Allure of the Multiverse* is ambitious. While Halpern is a lively, clear writer who includes helpful analogies for difficult concepts, the sheer volume of information he provides can overwhelm. Likewise, the "allure" of the book's title suggests a greater focus on the cultural fascination with the multiverse than it provides, with this discussion largely limited to the book's conclusion.

Nevertheless, this is a terrific guide to mind-bending physics and will reward rereading. Its complexity is admirable, and, in a cultural landscape where the multiverse is often oversimplified, I hope the teams behind the next multiverse-spanning blockbluster give it a read. ▮

# A wakeful wonderland

Nighttime can offer a world of creativity and connection with nature – especially for women, finds **Catherine de Lange**

Books

## Sleepless

**Annabel Abbs**

John Murray Press (UK, out now); G.P. Putnam's Sons (US, 14 February)

**MUCH ink has been spilled on sleep in popular science books (and in this magazine). We know how a lack of it can expose us to neurological conditions such as Alzheimer's or Parkinson's, as well as corrupt memory and the ability to regulate emotions. We also know how many hours we need and how "sleep hygiene" is key to getting more.**

**While true and important, this makes for unpleasant reading for the one-in-three people suffering from insomnia. Now, a book called *Sleepless* may help them find solace in the small hours.**

**Its author is Annabel Abbs, a writer and novelist gripped by insomnia after the sudden death of her father in 2020. Like many who lose someone they love, she busied herself with admin and caring for those around her. The nights, she decided, were her time to grieve.**

Biochemical changes in the brain at night can free us to explore our creative selves

**She gave up on chasing sleep and allowed herself to be drawn to the power of night and darkness.**

***Sleepless* chronicles the discovery of what Abbs calls her "night self", a side of her personality she had never met before. Each chapter examines a different facet of this self, weaving personal experience and cultural exploration of other insomniac women throughout history with scientific explanations of the physiology that might create a nighttime shift in personality.**

**Experiencing this shift is open to us all – if we dare examine it. Daring is a big part of the story, as we have evolved (for good and obvious reasons) to fear the dark. Much of Abbs's journey is spent attempting to conquer this fear, but also embrace it. Research shows, for instance, that people who fear the dark are more imaginative in semi-obscurity.**

**Fear of the night is a legitimate concern for women, who have often been unwelcome and vulnerable in dark spaces, with studies conducted in dimly-lit streets showing that men become more disinhibited and antisocial there. So finding a way to embrace the night can be particularly liberating for women.**

**But while this book is focused on the female relationship with the night, *Sleepless* is most successful when it ventures into nature after dark, detailing the wonder of a nocturnal planet few of us experience. Abbs's descriptions of the pleasures of sleeping, waking and walking under the night sky are a tempting reminder of adventure and connection with the wild.**

**For anyone who has gazed at the stars and felt calmer, Abbs cites experiments showing that our panoramic vision stills the amygdala, the brain's "threat centre". Then there is the cathedral effect, where high ceilings are said to encourage abstract thought and lower ceilings more detail-oriented thinking. What higher ceiling is there than the night sky? Writing at night, Abbs finds her imagination is unleashed, while Virginia Woolf, another insomniac, devised some of her wilder plots while laying awake.**

**In fact, Abbs credits fantastical novels such as Woolf's literary satire *Orlando* to the biochemical changes shown to happen at night. For example, levels of noradrenaline and cortisol, hormones that block connections between widespread brain areas to keep us focused, dip at night to leave tired brains more connected and able to free-associate. Dopamine levels also rise, fuelling imagination.**

**This switching between culture and science makes for an easy read, but can leave you wanting more, and the science sometimes feels shoehorned in. Where Abbs really succeeds is in subverting narratives about sleep, making connections between grief and insomnia many will relate to – and in revealing a wondrous night world.**

***Sleepless* is more than an antidote to sleep zealotry; it marks a special place to embrace and enjoy: "When the world sleeps, space opens up for those who need it."**

GORODENKOFF/SHUTTERSTOCK

## *New Scientist* recommends

**Graham Lawton**
**Feature writer**
**London, UK**

I've been bingeing **The Days** (pictured) on Netflix, a Japanese dramatisation of the 2011 Fukushima-Daiichi nuclear disaster. It's a slow burner, with a lot of focus on the opening

and closing of valves, which is more exciting than it sounds.

Even if you know exactly what happens, the narrative drive is powerful enough to keep you on the edge of your seat – how are they going to extricate themselves (and all of Japan) from this nightmare?

I've also been listening to Werner Herzog's self-narrated autobiography, **Every Man for Himself and God Against All: A memoir** (hat tip to my colleague Dan for his recommendation). His life is astonishing, from a childhood of poverty and isolation in post-war Bavaria to global acclaim as a film-maker, actor and author of singular eccentricity.

His failed attempts to become a ski-jumper and his relationship with explosive actor Klaus Kinski are just two of many highlights. And that voice...

NETFLIX

The sci-fi column

**Truth and fiction** *Him,* a provocative retelling of the story of Jesus, imagines the son of God as a transgender man. But is this novel by veteran sci-fi writer Geoff Ryman really about gender, wonders our new sci-fi columnist **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist*. *Gilgamesh*, the second novel in her *Sumerians* trilogy, is out later this year. You can find her website at emilyhwilson.com and follow her on X at @emilyhwilson and on Instagram at @emilyhwilson1

PLAINPICTURE/CÉLINE NIESZAWER

**In Geoff Ryman's novel *Him*, Jesus is a transgender man**

ON THE face of it, *Him* is a deliberately provocative book. Geoff Ryman's latest science fiction novel is, in short, a retelling of the story of Jesus in which he is transgender.

In its rendering, however, *Him* is surprisingly unprovocative. That isn't to say it is timid or dull. It is just more of a sweet, family story than you might expect. I found it a memorable and thought-provoking read.

Ryman's Jesus is called Yehush (although his name evolves throughout) and he is marvellous. He is a sort of mash-up of Alexander the Great and Joan of Arc, and is extremely mysterious. Your heart is always with him, even though we never see things from his perspective. He burns brightly, performs real miracles and, in the latter stages, is horribly aware that death is coming.

I am no theologian, but I think it is fair to say that this Jesus isn't the familiar figure one might remember from religious studies at school. Here, he is a higher power who is learning what it is to be human; he is also, as a fragment of that power, trying to teach God to be better. The world we find ourselves in is very recognisable from Bible stories, however: dusty towns, donkeys, Nazareth, Jerusalem, poverty, leprosy.

Our main point of view for much of the book is that of Yehush's mother, here named Maryam. Pregnant yet still a virgin, she has been forced to accept exile with a husband no one else would have chosen. She doesn't mind, because she has great expectations for her child.

**"Everyone accepts Yehush as a man. His followers don't care... But Maryam struggles to get past it"**

This brings us to the conflict that keeps you turning pages. Maryam can't accept Yehush's declaration of manhood. She insists, for years, on calling him a girl, or "it", or "the Cub". She thinks Yehush could have been a great female prophet, but has somehow strayed off course.

Everyone else accepts Yehush as a man. His followers don't care about his gender. Even among the stuck-in-the-mud villagers in Nazareth, there are no repercussions for him living exactly as he chooses. But Maryam struggles to get past it.

The book later focuses on Yehush's time as a prophet. This part is less accessible than the early struggles between Maryam and Yehush. That is mainly because Maryam, and her point of view, stay at home when Yehush leaves to walk the land.

By the time we join him on the road, his apostles and followers are already assembled, the politics is in full flow and you may struggle to fully understand what is going on, just as Maryam does, and as I did. Perhaps someone better versed in the New Testament and the historical knowledge we have of Jesus wouldn't have that problem, though.

So is this a book about gender or about Jesus, or both? I read it as a book about divinity. To embrace her son's true nature, Maryam has to cast off old ways of thinking, and her ideas of gender are just part of that. The point is you don't get to choose what the divine looks like. But that is just my reading: I am sure a Christian or someone with personal experience of being transgender might read it differently.

One last thing. *Him* is billed as science fiction. For me, that's a stretch. Yehush sometimes speaks of intelligent machines in the future and of parallel worlds. But that is all that separates this from historical fiction/fantasy.

Luckily, as we all know, genre is baloney! ▮

Book

**Him**

**Geoff Ryman**

**Angry Robot**

**(UK, US: out now)**

## Emily also recommends...

Book

**Stranger in a Strange Land**

**Robert A. Heinlein**

**Hodderscape**

*This 1961 classic is the book that* Him *most reminds me of, although the parallels may not be obvious straight off the bat. I suppose both are about divinity. It also has an all-time great first line: "Once upon a time when the world was young there was a Martian named Smith."*

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EOIN RYAN

# The quantum mind

With anaesthetics and brain organoids, we are finally testing whether quantum effects can explain consciousness. We may have misunderstood this long-derided idea, says **George Musser**

TWO weeks before the pandemic lockdown in March 2020, I flew to Tucson, Arizona, and knocked on the door of a suburban ranch-style house. I was there to visit Stuart Hameroff, anaesthesiologist and co-inventor, with Nobel prize-winning physicist Roger Penrose, of a radical proposal for how conscious experience arises: namely, that it has its origins in quantum phenomena in our brains.

Such ideas have existed, in various guises, on the fringes of mainstream consciousness research for decades. They have never come in from the cold because, as their critics argue, there is no solid experimental evidence that quantum effects occur in the brain, never mind a clear idea of how they would give rise to consciousness. "It was very popular to bash us," Hameroff told me.

But after a week interrogating the concept with him, I realised that his version of quantum consciousness, at least, is widely misconstrued. Partly, I think that is Hameroff's fault. He creates the impression of a single take-it-or-leave-it package. In fact, his idea is a series of independent proposals that each force us to confront important questions about the relationship among fundamental physics, biology and that ineffable thing we call consciousness.

Moreover, having seen some experiments that Hameroff was proposing during my visit come to fruition, it has become clear that his ideas can submit to experimental investigation. Researchers have now produced tentative evidence to suggest that fragile quantum states can endure in the brain, and also that anaesthetics have an impact on them.

So is it time to start taking the idea of quantum consciousness more seriously?

Hameroff and Penrose's proposal is known as orchestrated objective reduction, or Orch OR. In short, it says that consciousness arises when gravitational instabilities in the fundamental structure of space-time collapse quantum wave functions in tiny structures called microtubules that are found inside neurons – and, in fact, in all complex cells. But a statement like that requires some serious unpacking, starting with quantum mechanics.

Quantum theory, in its textbook formulation, says that a particle exists in a cloud of probabilities – where it can appear both here and there, say, simultaneously – until it is snapped into a definite, "classical" state upon observation. This is what physicists refer to as the collapse of the quantum wave function, a mathematical entity that describes all possible states of a particle before it is observed. But we don't know what, if anything, induces collapse, and there are all manner of interpretations of what is going on.

## Igniting experience

In the late 1980s, building on earlier ideas, Penrose proposed that "objective" wave function collapse is a result of the inherent incompatibility of quantum theory and general relativity, which describes gravity as the result of mass warping space-time. Unlike quantum fields and the particles they manifest, gravitational fields don't exist in an uncertain state – at least as far as we can tell. Penrose's idea, then, was that any observation of a quantum particle forces an interaction with the classical gravitational field associated with the apparatus, creating a conflict that drives the quantum particle to collapse into a definite state.

It was a big leap, to say the least. But Penrose went further, postulating that each time a quantum wave function collapses in this way in the brain, it gives rise to a moment of conscious experience.

This is where Hameroff entered the picture. Since the 1970s, he had been studying proteins called tubulin and the hollow, cylindrical microtubule structures they form, trying to figure out their role in cell division. Crucially, they seemed to be affected by anaesthetics, which cause loss of consciousness. This led Hameroff to posit that microtubules inside neurons could be exploiting quantum effects, somehow translating gravitationally induced wave function collapse into consciousness, as Penrose had suggested.

Penrose and Hameroff published their Orch OR paper in 1996, to much incredulity. On the one hand, here was an audacious attempt to bridge the quantum and classical worlds, while explaining the origin of our moment-to-moment experience. On the other, critics complained that they had committed the fallacy of minimising mysteries: just because consciousness and quantum mechanics are both mysterious doesn't mean that those mysteries must have a common source. And although Penrose, Hameroff and their collaborators developed the concept in more detail over the following decades, without solid experiments to back their ideas up, Orch OR remained beyond the pale of mainstream consciousness research.

Now, several groups have begun to demonstrate that it is possible to test one cornerstone of Orch OR, the idea that quantum effects could exist in the brain, and the early results are intriguing.

During my stay in Tucson, Hameroff was applying for a grant to conduct some experiments, and the results of one came ›

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out in early 2023. Aarat Kalra and Gregory Scholes, physical chemists who were both then at Princeton University, led a study into how energy – absorbed in the form of light – propagates through microtubules. They tagged these structures along their length with a fluorescent dye in order to observe this. To their surprise, energy diffused about five times further than expected according to classical calculations, suggesting a quantum phenomenon was at play in the microtubules. "It's likely some kind of quantum resonance," says Scholes.

## Quantum traces

Remarkably, when they doused the microtubules with two general anaesthetics, etomidate and isoflurane, the diffusion length fell slightly but significantly, from 7 to 6 nanometres. "These anaesthetics do interact with microtubules, which is interesting," says Scholes, since it would link the quantum effects to consciousness.

The trouble is this experiment was done on isolated microtubule compounds in test tubes – a far cry from the complexities of actual neurons inside brains. Physicist Max Tegmark has argued that even if quantum effects do exist somewhere in biology, the brain is too wet, warm and noisy for them to persist long enough across a sufficient number of neurons to sustain the kind of quantum processing that could plausibly explain our consciousness.

Yet there are tantalising hints that they do persist. In 2018, a team led by Na Li at Huazhong University of Science and Technology in Wuhan, China, anaesthetised 80 mice using four different isotopes of xenon gas. By definition, isotopes are chemically identical – as they have the same number of protons in their nucleus, but a different number of neutrons – so you would expect them to have identical effects. But the isotopes that contained an odd number of neutrons in their nucleus, giving them a quantum property called "spin", were found to be about 20 per cent weaker in their anaesthetic effects. Among other things, spin makes the nuclei act like tiny bar magnets, and in general such behaviour can only be explained using the equations of quantum mechanics. So Li and colleagues argued that their result, by implicating spin in the action of the anaesthetics, suggests that consciousness relies on quantum phenomena.

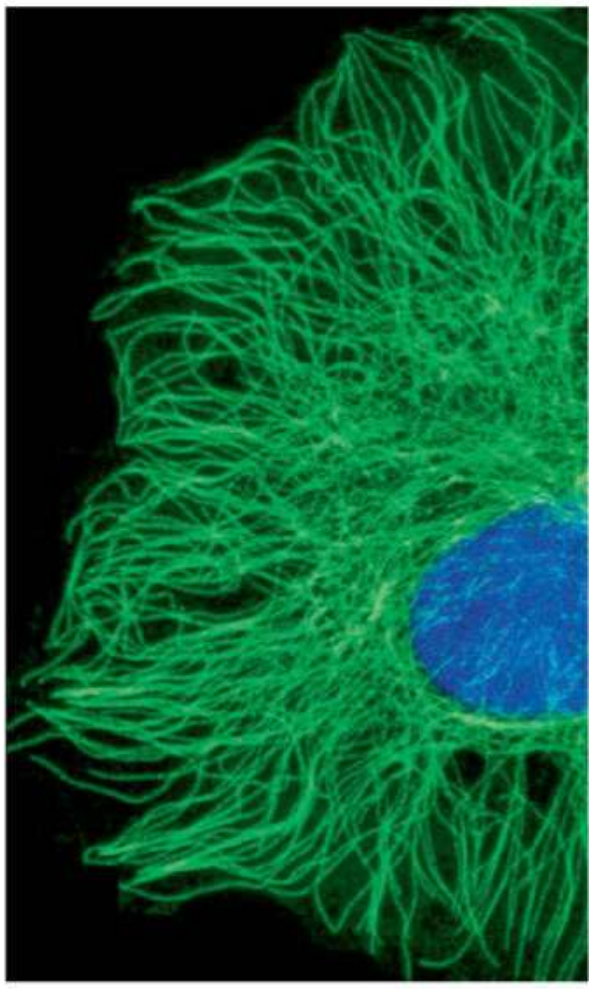
Many remain unconvinced. "This may just be wrong," says Hartmut Neven, vice president of engineering at Google, who in 2017 was part of a team that looked for differences in the action of neurotransmitters altered to give their atomic nuclei the quantum property of spin, and found none. Nevertheless, Neven remains sufficiently intrigued that he has assembled another team to examine the result reported by Li further, which is taking two approaches.

In the first, Luca Turin, a biophysicist at the University of Buckingham, UK, will use fruit flies to study the anaesthetic strength of different xenon isotopes. Meanwhile, neuroscientist Kenneth Kosik at the University of California, Santa Barbara, will do the equivalent test on brain organoids. These mini-brains, comprising several million cells in a ball about the same size as a lentil, are grown in a lab by mimicking what happens during the natural growth of embryos.

Brain organoids are much easier to poke and probe than a natural brain. "We have a really great recording system, with 20,000 electrodes" that monitor patterns of neural activity, says Kosik. Moreover, despite their artificial origins, the organoids are uncannily brain-like. Their neurons wire themselves up spontaneously, says neuroscientist Alysson Muotri at the University of California, San Diego. "As far we can tell, they make the connections they would do in the brain," he says. In 2019, Muotri's group found that brain organoids exhibit brain waves of similar complexity to electroencephalogram readings from a newborn human baby's brain.

In other ways, they are quite different. Organoids model only one part of the brain and they aren't embedded within a body, so don't receive any sensory input. These differences suggest an organoid isn't sentient. "I would say it's not conscious – pretty firmly," says Kosik. Muotri, however, is less sure.

Whether or not organoids have inner experience, their electrical activity gives consciousness researchers something tangible to measure. And it is already clear that these bundles of neurons respond to anaesthetics. In 2022, Kosik and his colleagues found that diazepam – which has a sedating, anxiety-relieving effect by enhancing the effect of a neurotransmitter called GABA – made the organoids' electrical bursts more regular. In the same year, Muotri and his group found



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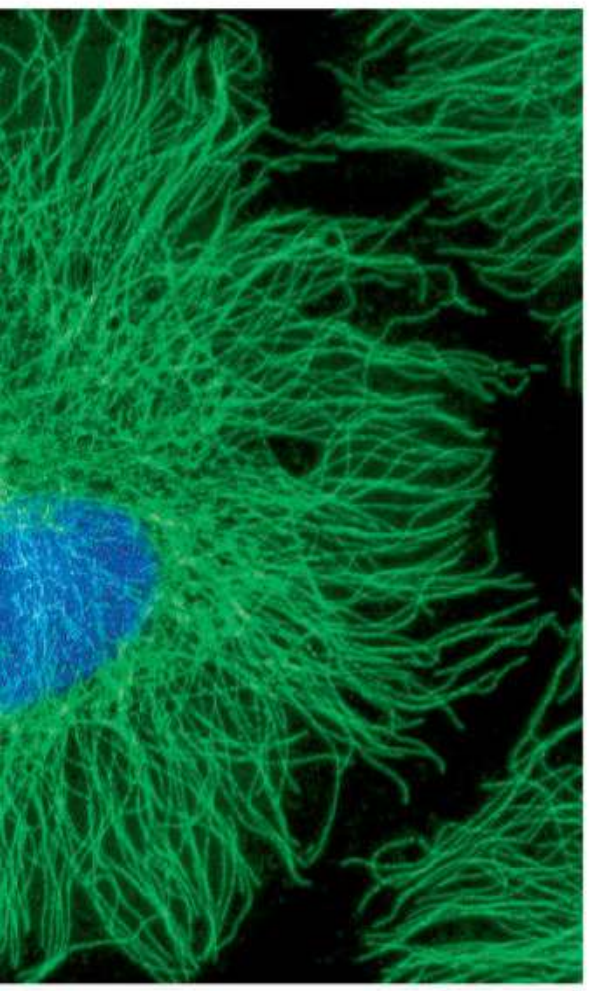
**Migrating birds may use quantum effects as a kind of compass**



**Quantum effects could be occurring in cells' microtubules (green)**

that the electrical activity of brain organoids implanted in mice was dampened by isoflurane anaesthetic.

Kosik and others in Neven's group plan to do much the same with xenon anaesthetic. "Let's measure all the different activity signals that they normally look at [in brain organoids] and see how they are differentially suppressed by the different isotopes," says Neven.

If they do confirm a difference, the challenge would be to figure out why it arises. "Where, within a biological system, is that difference being detected?" asks Kosik, who suspects it would entail some kind of quantum effect.

## Biological computer

One possibility lies in something called a "radical pair" mechanism, which features in the poster child of quantum biology: a bird's inbuilt compass. Here, the idea is that a chemical bond in a cell ruptures, creating a pair of chemically reactive entities known as radicals that each has an odd, unpaired electron. Electrons have the quantum property of spin and so act like bar magnets that are sensitive to Earth's magnetic field. When these radicals eventually react, the outcome will depend on the strength and orientation of the magnetic field. The thinking is that the bird is sensitive to this in a way that allows it to tell north from south. The process is highly quantum as the radical pair electrons are entangled, which means that they act as a single quantum object, even though they are some distance apart.

In anaesthetised brains, the magnetic field that steers the outcome for the radical pairs would be generated by the xenon atomic nuclei – rather than Earth's iron core. "It provides a way for the nuclear spin [of an anaesthetic] to influence an electron spin and then for the electron spin to influence chemical reactions," says Christoph Simon, a physicist at the University of Calgary, Canada. In 2021, Simon and his colleagues modelled this quantum effect in computer simulations with anaesthetic xenon isotopes. Peter Hore, a chemist at the University of Oxford who studies the biological compass, deems it "interesting but very speculative", as the model makes various uncertain assumptions.

Such a spin-dependent mechanism would be hugely consequential for medicine, as it would behove doctors to consider magnetic interactions when administering anaesthetics and other drugs. "That is our main experimental prediction," says Simon. But it could have deep implications for how we understand the source of consciousness, too.

If the action of anaesthetic in brain organoids proves to be partly quantum in nature, it would make Penrose and Hameroff's proposal more plausible. First, it would show that quantum effects do operate in the brain, countering Tegmark's influential critique. Second, those effects evidently have some relation to consciousness, as the involvement of anaesthesia suggests. And third, the specific mechanisms that are being proposed may even make contact with Penrose and Hameroff's conjectures. Simon and Hadi Zadeh-Haghighi, also at the University of Calgary, argued in 2022 that a similar radical pair mechanism might occur in microtubules.

But even then, these experiments still fall short of what Penrose and Hameroff have in mind when it comes to Orch OR. It is a long way from a weakening of anaesthetic potency to a full-blown microtubule quantum computer that assembles all our sensory input and memories into a rich stream of consciousness. Furthermore, these neurobiology experiments say nothing about Penrose's physical theory of "objective" wave function collapse. "The collapse model can be tested independently from the biological system," says Cătălina Curceanu at the Italian National Institute for Nuclear Physics, who has performed just such a test. Though her work hasn't ruled out objective collapse – and may never, since the models contain plenty of wiggle room – Penrose's hypothesis is yet to be corroborated.

In fact, the legacy of Hameroff's experiments, and others pursuing the possibility of quantum consciousness, may have little to do with Orch OR and the purported quantum behaviour of microtubules. By searching for answers, researchers have realised that the brain may make use of fragile quantum effects despite the hurly-burly inside a living organism. This would suggest that life evolved ways to shield those effects from disruption. "Multicellular organisms have been relentlessly optimised over 600 million years," says neuroscientist Christof Koch at the Allen Institute in Seattle, Washington.

**"There are tantilising hints that quantum effects do persist inside the brain"**

One tantalising idea, which Scholes explored in a recent paper, is that evolution came up with a different model of quantum computing from an engineered system with its own version of qubits. Imagining these possibilities may suggest new experiments to search for quantum effects in the brain. "What we really want to know is what to look for," says Scholes. He credits Penrose and Hameroff with driving science forward regardless of whether their proposal is vindicated: "Even if it turns out not to be exactly correct, but it inspires a field, then there's going to be advances."

Koch agrees. Although he considers Penrose and Hameroff's idea a long shot, he says it is still worth exploring: "They push us to think much harder about the limits between the classical and the [quantum] world and to what extent these limits apply to biology." ▮

George Musser is a writer and editor. He is the author of *Putting Ourselves Back in the Equation.* @gmusser.bsky.social

# Should the oceans be cleaned up?

Efforts are under way to clear the Great Pacific Garbage Patch. Is that really a good idea, asks **Andrew Kersley**

OCEAN VOYAGES INSTITUTE/ZUMA WIRE/SHUTTERSTOCK

IT WAS a glorious sunny day in September 2023. Excitement filled the air and a rainbow stretched across the horizon as the team slowly hauled a giant net out of the glistening sea. The Ocean Cleanup project was in the North Pacific, trialling its System 03 – essentially two ships dragging a 2.2-kilometre-long net designed to remove as much trash as possible. On this occasion, filmed for a promotional video, it managed a record-breaking 18 tonnes in a single scoop.

The Ocean Cleanup was founded in 2012 on a simple premise: trawl ocean plastic hotspots and sweep up the floating refuse. Now, after years of testing and improving its technology, the organisation says it is ready to start systematically removing the Great Pacific Garbage Patch, a vast collection of plastic waste between Hawaii and California.

That sounds like a laudable goal. But in recent years, marine scientists have been warning that efforts to mechanically take plastics out of our seas are not only futile, but also potentially harmful. Futile, because we have learned that much of the plastic waste in the oceans is too small or too out of reach to be captured. And harmful, perhaps, for two reasons: because the latest research shows ocean garbage patches are home to all manner of marine life and because clean-up operations could distract from efforts to stem the flow of such waste at source.

So, given what we know now about the extent of ocean plastics and the nature of these collections in the Pacific and elsewhere, the question has surfaced: is cleaning up these garbage patches a good idea, after all?

Oceanographers were aware that discarded plastic was accumulating in hotspots in the Pacific since the 1970s. But the problem only surfaced in the public consciousness thanks to the efforts of boat captain Charles Moore, who came face to face with the true extent of it in 1997 on his way back to the US mainland from a two-week yacht race in Hawaii.

Sailing through the North Pacific Subtropical Gyre, a vortex formed by ocean currents that most sailors avoid owing to a lack of wind, he found himself surrounded by plastic waste: everything from bleach bottles, volleyballs and truck tyres to parts of a TV. "As I gazed from the deck at the surface of what ought to have been a pristine ocean, I was confronted, as far as the eye could see, with the sight of plastic," Moore recalled in 2003.

He went on to work with oceanographers to chart the extent of the problem and, crucially, raise awareness. As they slowly mapped and studied 1.6 million square kilometres of sea between Hawaii and California, they began to refer to it as the "Eastern Pacific Garbage Patch". Strictly speaking, that eastern patch forms part of a wider system that also includes a western patch off the coast of Japan and a "convergence zone" that acts as a highway moving debris between the two. But these days, when most scientists refer to the Great Pacific Garbage Patch, they are referring to the eastern section. There are similar trash-collecting gyres in the Atlantic and Indian Oceans. However, the Great Pacific Garbage Patch, which is twice the size of Texas, is the biggest and by far the most infamous. Despite this, or maybe because of it, the patch has been shrouded in misconceptions – and we are still learning about it today.

Back in 2018, the estimated amount of plastic it contained was revised upwards to at least 79,000 tonnes, four to 16 times as much as previous estimates. The source of the plastic was long thought to be household refuse. But analysis of over 6000 pieces of debris collected from the patch by The Ocean Cleanup in 2022 found that as much as 86 per cent of the identifiable waste could come from the fishing industry. "Plastic that comes from land and rivers tends to stick around coastlines because of the tides, winds and currents. Just a small part makes it offshore," says Matthias Egger, head of environmental and social affairs at the project. Fishing, meanwhile, is often done far out at sea.

The Great Pacific Garbage Patch is often referred to as an artificial island, giving the impression of a more-or-less solid mass. However, big chunks of plastic floating in the patch are relatively few and far between. It is more of an oceanic soup made up of billions of tiny shards, known as microplastics, each measuring less than 5 millimetres across. Swimmer and conservation activist Benoît Lecomte, who swam over 500 kilometres through the patch in 2019, says "it was like swimming in a snowstorm, you have this tiny plastic all around you". Sure enough, of the estimated 1.8 trillion pieces of plastic the patch contains, some 94 per cent are thought to be microplastics.

Many of the risks posed by these tiny fragments to marine life are well-documented. The bio-accumulation of microplastics has been linked to impaired thyroid function in mammals, illness-causing bacteria in seabirds and digestive issues in crustaceans. But some problems are just coming to light. In 2021, Karin Kvale, then at the GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany, and her colleagues observed that prolonged ›

**Fish caught up in discarded nets in the Great Pacific Garbage Patch**

exposure to microplastics severely damages the function of zooplankton, adversely affecting their ability to turn atmospheric carbon dioxide into oxygen. In that sense, the researchers found, the presence of microplastics is undermining the ocean's ability to sustain marine life.

## A new ecosystem

Yet perhaps the most interesting thing we are learning about the Great Pacific Garbage Patch is that the larger chunks of plastic, of which there are many despite the fact they make up only a small percentage of the total, are now providing a novel habitat for marine life.

In 2022, researchers including Rebecca Helm, then at the University of North Carolina, Asheville, studied samples gathered by Lecomte during one of his epic swims. They found that the patch is teeming with aquatic life – mostly tiny floating "neustons", surface-dwelling aquatic organisms ranging from snails to jellyfish. "One of the tragedies of naming the North Pacific Gyre the garbage patch is that it erases the reality that it is, and always has been, an ecosystem," says Helm, now at Georgetown University in Washington DC.

A year earlier, Linsey Haram at the Smithsonian Environmental Research Center in Maryland, and her colleagues, had found that 90 per cent of marine debris analysed was now home to plants and animals, ranging from tiny invertebrates known as bryozoans and barnacles to small marine insects and crabs. Then in 2023, a study led by Haram found that three-quarters of the species living on the plastic were coastal, rather than those of non-coastal, or pelagic, waters. This adds to a growing body of evidence that suggests plastic is creating a "neopelagic" ecosystem, enabling coastal species to adapt to living out at sea. "The plastisphere may now provide extraordinary new opportunities for coastal species to expand populations into the open ocean and become a permanent part of the pelagic community," wrote Haram and her colleagues, "fundamentally altering the oceanic communities and ecosystem processes in this environment."

> "Naming the North Pacific Gyre the garbage patch erases the reality that it is, and always has been, an ecosystem"

**Plastic collected by The Ocean Cleanup from the stomach of a sea turtle**

THE OCEAN CLEANUP

## Giant trash bag

You could be forgiven for thinking that, on balance, clearing up this ocean plastic must be a good idea, and The Ocean Cleanup is certainly pushing ahead. Its system for doing so has changed over the years, but the fundamentals are simple. Shaped like a horseshoe protruding out from a central reservoir, two 2.2-kilometre-long "wings" push the plastic towards a floating barrier with a net dangling up to 4 metres below the surface. As it is pulled behind two boats, plastic collected by the net is slowly funnelled to the middle of the barrier, where it moves into a central "retention zone" – essentially, a giant trash bag.

So far, the process has collected several hundred tonnes of plastic in total. Its newly launched system is now ready for full-scale operations, capable of scooping up many tonnes of waste in one go, as the 2023 expedition demonstrated. Even within the patch, currents create areas of denser plastic waste, so the organisation is now using machine learning to pre-empt and track those, to make its efforts more efficient.

But, as critics have pointed out, it isn't as simple as just sweeping the problem away. For starters, collecting large bits of plastic isn't going to deal with the tiny plastic particles that make up most of the waste in the Great Pacific Garbage Patch. While there have been some interesting studies into nature-based solutions to the microplastic problem – one from the Plymouth Marine Laboratory in the UK found that mussels can naturally filter those fragments from water – there is currently no viable way to get microplastics out of the ocean, let alone at the scale needed.

Even when it comes to the larger pieces of plastic in the patch, there are reasons to question the idea that we should seek to remove them. One of the main issues with the system is animals that are accidentally caught

## The plastic fight

**In the two and a half decades since the Great Pacific Garbage Patch (see main story) was discovered, recycling rates have shot up and countries have begun banning or taxing some single-use plastic. While the amount of plastic produced each year hasn't started to fall yet, the UN is working on a new global treaty to control the production and disposal of the material, a move that conservationists hope could set limits on the volume of new plastics, or at least improve the process of disposal and recycling. "I think it's actually quite amazing how quickly we're moving," says Matthias Egger at The Ocean Cleanup, a project to tackle marine plastic patches.**

**It is impossible to say how much of this is thanks to public awareness of the garbage patch, but since its rise to infamy "the notion of a floating island of trash has done more good than harm", says Nick Mallos at the Ocean Conservancy. "That visibility, the almost overnight media sensation, elevated the broader societal issue of plastic pollution in a way I don't think any other media or marketing effort could have done."**

ALEX MUSTARD/NATUREPL.COM

THE OCEAN CLEANUP

**The Ocean Cleanup uses boats to pull a net (below left) to catch ocean plastic (below right). But animals like a paper nautilus can attach to the waste (left)**

up in the net. "When The Ocean Cleanup posted some of their first pictures of their plastic capture, I went through and circled the hundreds of animals that were also caught in their net," says Helm.

The current system tries to minimise this bycatch in various ways. By moving at half the pace of a walking human, with multiple openings, there are meant to be plenty of opportunities for animals to evade being caught or to escape. Disruptive lights and sounds are also designed to keep them away. Egger says that, as a result, only 0.3 per cent of the catch was marine life when using the most recent versions, but this was by weight, so large items of plastic could skew the results.

Despite its precautions, the system can't stop all of the collateral damage. Neustons are almost impossible to separate from waste, for one. An environmental impact assessment by the group from 2021 suggested that, even at the slowest speeds, the previous system would pick up millions of these creatures a day.

The emerging picture of a neopelagic ecosystem might complicate matters, too. Egger, who was a co-author of the 2023 study led by Haram, describes these coastal species as "invasive" and argues that they could be "competing for the very limited resources for the species that are naturally occurring out there". This is an argument for getting rid of them. But Helm says many of the coastal species have a long history of riding on more natural ocean flotsam. "If disturbances to the ecosystem by plastic is the real problem, is further disturbing the ecosystem to clean up plastic actually a solution?" he asks.

All of this aside, an overarching issue is whether these areas are worth spending so much effort on at all. The Great Pacific Garbage Patch is, after all, just the sharp end of a global plastics crisis. Each year, an estimated 11 million tonnes of plastic trash goes into the ocean each year. Only 1 per cent ends up in garbage patches. Scientists just aren't sure where the other 99 per cent is. Thanks to currents, they think a lot of it stays within 160 kilometres of the shore, moving along coasts and up and down from the seafloor, slowly being broken down. A large share is also thought to be trapped in Arctic ice. Why target plastics caught in gyres, given they make up such a small amount of the ocean plastic?

It isn't as if these garbage patches are easy to get to, either. "All of the gyres exist in the very centre, more or less, of the ocean basins," says Nick Mallos at the Ocean Conservancy organisation. "It's very costly, time-intensive and fuel-intensive to actually get out there." He cites research from Imperial College London, published in 2016, that shows clean-up efforts near shores and coastal environments are more efficient at removing plastic.

Then there is the question of what happens to the waste once it has been collected. The hope is that it can be reused or recycled in some way. The Ocean Cleanup, for example, announced a partnership with Kia in 2022 that would see recycled ocean plastic used in the car-maker's new models. But the breakdown of plastic that has been in the ocean for a long time often makes that kind of outcome impossible, forcing it to be put into landfill, where it can still contaminate the soil and air.

## Turn off the tap

In November 2023, a collaboration including Richard Thompson at the University of Plymouth in the UK cautioned against physical clean-ups as the main way to tackle ocean plastic, calling them a fallacy. The resulting report cites a frightening figure: that 200 of The Ocean Cleanup's devices running for 130 years would only capture 5 per cent of the world's floating plastic. "The concern here is that there's a distraction to something that's really managing symptoms, rather than solving the root cause," says Thompson.

The Ocean Cleanup is in favour of changing the way we consume plastic (see "The plastic fight", p38). In recent years, it has put an increasing amount of work into building machines that intercept plastic flowing down waterways, with systems operating in multiple rivers. But "even if we stop emissions, there's already a lot of plastic doing a lot of harm to the marine environment", says Egger. He thinks the two solutions complement each other, since the company's data on types of plastic and where it is coming from can help people who are working on prevention. "A clean-up can do much more than clean up," he says.

Still, that doesn't change the fact that 430 million tonnes of plastic are made per year, two-thirds of which becomes waste. "Cleaning up the open ocean is a Sisyphean feat," says Mallos. "These things can come in parallel," says Thompson. "But we need to be putting 1 per cent of our efforts into this kind of clearing and 99 per cent into turning off the tap." ▮

Andrew Kersley is a freelance writer based in London

# Avoiding spermageddon

Sperm decline is accelerating across the world. How do we reverse the trend, asks **David Robson**

THE year was 1974. As newspaper columnists were busy wringing their hands over the development of in-vitro fertilisation and the prospect of "test-tube babies", an alarming discovery about male fertility completely escaped their notice.

Comparing contemporary semen samples with historical data, two doctors in Iowa named C. M. Kinloch Nelson and Raymond Bunge showed that there had been a drastic shift in men's sperm counts over the previous two decades. In 1951, each millilitre of semen contained 107 million sperm; by the 1970s, that figure had dropped by more than 50 per cent – to just 48 million. The average volume of semen from a single ejaculation had fallen too.

By the 1990s, the issue started catching considerably more scientific attention, although some researchers were still sceptical. They blamed differences in techniques, or the fact that studies were mostly on men already having treatment for infertility. Such doubts are now shrinking. "There is a huge body of scientific evidence showing this decline," says Albert Salas-Huetos at the University of Rovira i Virgili in Spain.

For researchers like Salas-Huetos, the big question is no longer whether this "spermageddon" is really happening, but why and what to do about it. Studies are beginning to shed light on environmental toxins that may be to blame, as well as other lifestyle factors contributing to the problem. With a better idea of the prime suspects, we may finally be able to put the brakes on this trend, or even reverse it.

Globally, around 1 in 6 people have trouble conceiving, according to a recent report by the World Health Organization. There are many potential causes, but between 30 and 50 per cent of cases are linked to problems with the quantity and quality of semen. It may be that the total number of sperm is simply too low, or that the tadpole-like cells struggle to swim – a problem called poor motility – which vastly reduces the chance that sperm can reach the ovum, or egg cell. Some may have genetic defects within the chromosomes they are carrying, known as DNA fragmentation.

Shanna Swan, a reproductive epidemiologist at the Icahn School of Medicine at Mount Sinai, New York, has led many of the most eye-catching studies. Her interest began in the 1990s, when she was asked by the US National Academy of Sciences to independently review a study from Denmark reporting rapid sperm decline. Swan was initially sceptical: she suspected that the researchers might have missed some confounding factor in their analysis. When she crunched the data, however, she kept finding the same rate of decline predicted by the Danish team. "We didn't change the slope at all – not down to the second decimal place," says Swan.

Her conviction has only increased over the subsequent decades. In 2017, she and her colleagues published a meta-analysis that

SPENCER WILSON

considered data from 185 studies of more than 42,000 men between 1973 and 2011, making it the largest of its kind. Swan's team examined two different measures: the concentration of sperm in a millilitre of semen and the total number of sperm in the sample. In North America, Europe, Australia and New Zealand, both figures seemed to be falling at a rate of around 1.5 per cent per year on average, resulting in a 50 to 60 per cent drop over the whole period.

If the decline continued at this rate, the median sperm count would reach zero by the mid-2040s. Within a generation, "we may lose the ability to reproduce entirely", the magazine *GQ* declared in 2018.

At the time of this analysis, Swan and her team didn't have enough data to draw strong conclusions about sperm counts in the rest of the world. They have now filled this gap in knowledge with additional data from South America, Asia and Africa. The ensuing paper, published in 2023, reported a decline on every continent studied.

"Excess body fat totally disturbs the hormonal balance you have to maintain to produce sperm"

Such studies do have some limitations. Meta-analyses can be skewed by differences between datasets. Counting sperm is a fiddly job and the technology used to do it has changed over the years, which may bias the reported numbers. Nevertheless, the latest studies control for this potential bias and the pattern remains, says Richard Lea at the University of Nottingham, UK.

Then there is comparative evidence from man's best friend. Vets regularly test stud dogs' sperm quality, which is carefully recorded for controlled breeding programmes. This provides an excellent source of data to study potential changes in dog fertility over time. Lea and his team recently analysed data from a lab measuring dogs' sperm motility between 1988 and 2014. Crucially, the lab's methods had remained the same across the 26-year period, eliminating any possibility that methodological changes would bias the results. "The decline in sperm quality we saw in dogs parallels that seen in humans," says Lea.

There is one caveat that is still taken seriously. It isn't yet clear how important a decline in sperm is for overall fecundity. We see large variation in sperm count between men who don't have any significant health issues, but the absolute figures don't seem to make a big difference to the chances of conception until they dip below a very low threshold. "And all of the average sperm counts are still above the level required for fertility," says Marion Boulicault at the University of Edinburgh, UK. It is possible, she says, that we are simply witnessing natural variability within a healthy range, rather than an endless decline.

Even so, scientists investigating the trend are concerned with the speed of the decline, which doesn't show signs of slowing. Indeed, Swan's research suggests it may even be accelerating. "If you see a 50 per cent decline in 50 years, that sets off an alarm," says Salas-Huetos. ›

Lea, meanwhile, points out that the reduced sperm counts coincide with a higher prevalence of numerous other global reproductive issues. Increasing numbers of children are being born with genital malformations, for instance, and rates of testicular cancer in young men have also been on the rise. "That data's really robust," he says.

The suggestion is that there may be some underlying environmental or lifestyle factors driving all these different trends. This is now the primary area of interest for Swan, and she says there is a growing body of evidence that chemicals may play a major causal role.

For decades, pollutants called endocrine-disrupting chemicals (EDCs), have been on our radar as the prime suspects behind infertility in men and women. These are thought to interfere with hormonal signalling and include common chemicals found in some plastics and pesticides

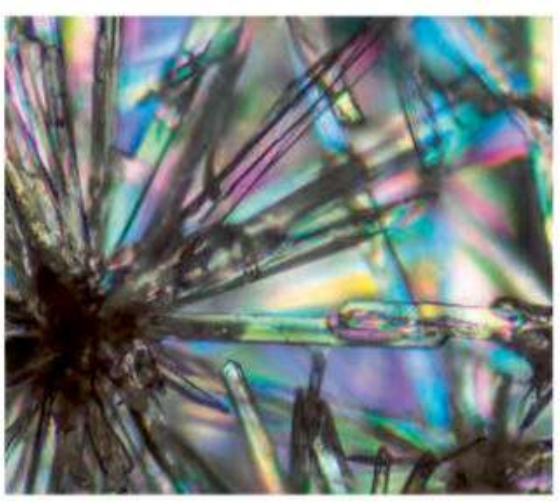
The drop in sperm count today could be the result of EDC exposure during the earliest months of development. We know that fetal growth is, in part, governed by levels of sex hormones, and EDCs could upset this process. Animal studies have shown that exposure to EDCs during critical windows of fetal development can result in genital malformations and a reduced ability for males to produce sperm later in life. Likewise, research examining people who have been exposed to EDCs through their occupation has also shown links between exposure and decreases in sperm count, viability and motility.

Common pollutants can make their way into the testes through the diet and the surrounding environment. To test the effects that this may be having on sperm quality, Lea's team recently incubated samples of dog and human sperm with different concentrations of diethylhexyl phthalate and polychlorinated biphenyl 153. The former is used in cosmetics, personal hygiene products and furniture materials. The latter, once widely used in industrial products such as paint and rubber, was banned internationally in 2001 after being deemed potentially carcinogenic, but it persists in soil, water and building materials. The result was reduced motility and higher rates of DNA fragmentation in sperm. Swan's research has also shown a relationship between phthalates and low sperm count. Other studies have found similar results for bisphenol A, or BPA, a chemical used to make rigid plastics, including food storage containers and refillable drinks bottles. For instance, one showed that men who were occupationally exposed to BPA were more likely to have a reduced libido, erectile dysfunction and decreased sperm quality.

Although the UK's Food Standards Agency says that the levels of BPA typically detected in food aren't considered harmful, it has banned its use in items intended for infants. The agency says that it is reviewing the latest evidence and may revise restrictions on BPA in the future.

In any case, some manufacturers have replaced BPA with other chemicals, such as bisphenol F (BPF) and bisphenol S (BPS). A recent study analysed the effect of BPA on bulls' sperm, comparing it with that of BPF and BPS. It found that BPA was the worst offender, but BPF also decreased sperm motility, energy and capacity to fertilise an egg. BPS didn't have any significant effects.

**The chemical BPA has been linked with low sperm quality**



PRILL MEDIENDESIGN/ALAMY

## Added Weight

It isn't just environmental toxins that are in the crosshairs. The role of diet in sperm decline has also come under scrutiny. From 1980 to 2019, the number of men and boys in England aged 16 and over who were obese rose from 6 per cent to 27 per cent, with similar trends across many other countries.

Multiple studies have found that men who are overweight produce less semen, have a lower overall sperm count and have reduced sperm motility. This, in turn, can influence the outcome of fertility treatments. In 2022, a team of researchers, including Salas-Huetos, tracked the success rates of 176 couples visiting Massachusetts General Hospital Fertility Center and measured the sperm counts of the men. A 5-centimetre increase in a man's waist circumference was associated with a 6.3 per cent drop in sperm concentration and a 9 per cent reduction in the chances of a live birth for each cycle of treatment.

Salas-Huetos suggests that inflammation

## What causes sperm decline? Fact and fiction

### Mobile phone use

**A meta-analysis of 18 studies identified an association between mobile phone use and reduced sperm motility, viability and concentration: the greater the use, the worse the outcome. The electromagnetic waves used to transmit data are hypothesised to contribute to genetic damage. The evidence is often criticised for not being robust enough, though. Shanna Swan at the Icahn School of Medicine at Mount Sinai, New York, is sceptical. "It's potentially extremely important, but I haven't seen convincing evidence yet," she says.**

### Tight undies

**There is a commonly held belief that tight underwear has an affect on sperm quality, possibly due to scrotal heating. A handful of studies do show an association between wearing tight underwear and lower semen quality. However, these studies are small, haven't been linked to lower fertility and are mostly carried out on men already attending fertility clinics.**

### Cycling

**Several small studies appeared to support the idea that pressure from saddles could disrupt blood flow or cause tissue damage that reduces sperm health. However, in 2014, a study of more than 5000 cyclists, the largest of its kind, refuted this idea, finding no relationship between cycling and infertility. Some small studies have suggested that extreme cycling training may harm sperm quality (see main story), but these findings haven't been tested on larger numbers of people.**

SHUTTERSTOCK/DUNCAN ANDISON

**A study of 5000 people showed no link between cycling and infertility**

is to blame. Excess body fat produces inflammatory molecules that can wreak havoc on other tissues, including those of the genitals, and reduce the production of testosterone. "The hormonal [balance] that you have to maintain to produce sperm – it is totally disturbed," he says.

The nutritional quality of food may also be key. A 2019 study found that men who regularly consume fruits, vegetables, nuts and fish have higher sperm concentrations with greater motility than those with less balanced diets. These foods tend to be high in antioxidant compounds, which help to neutralise rogue molecules called free radicals. The production of semen seems to be particularly sensitive to this form of free radical stress, so any nutrients that mop up these molecules may contribute to sperm health. The presence of omega-3 fatty acids – which are known antioxidants with anti-inflammatory properties – appears to be particularly important in predicting sperm quality, according to one 2020 study. High sugar consumption, in contrast, is linked to reduced sperm quality.

Since the covid-19 pandemic began, more attention has also been given to the impact of viruses on sperm. Several studies have shown how infection with covid-19 reduces sperm counts and motility, potentially due to the virus interfering with the later stages of sperm development, or fever upsetting the delicate homeostasis needed to grow healthy sperm.

This decline usually reverses as the infection wanes, although one study of men visiting a fertility centre showed that a subset still had decreased sperm health more than three months after covid-19 infection.

There is some good news. If obesity, diet and infection are affecting sperm production, lifestyle interventions and vaccinations may be able to offset a fertility crisis – and a handful of randomised clinical trials over the past few years already provide grounds for optimism.

Emil Andersen at the University of Copenhagen in Denmark and his colleagues asked 56 men who were obese to reduce their calorie intake to just 800 calories a day for eight weeks. Publishing their results in 2022, Andersen and his team found that participants lost 16.5 kilograms on average, and their sperm count increased by more than 40 per cent. Tracking the men for a year after the diet showed that these improvements continued for as long as they kept the weight off, but disappeared if they regained the lost kilos.

## Get moving

Salas-Huetos and his colleagues, meanwhile, examined the benefits of adding 60 grams per day of walnuts, almonds and hazelnuts to men's diets for 14 weeks. These nuts are all high in antioxidants, which the team suspected would help reduce genetic damage to sperm. Sure enough, the men adhering to this programme showed increased sperm counts and motility, and reduced DNA fragmentation, while those continuing with their standard diet didn't show any improvement.

There may be many different routes to reaping these benefits. An Italian study from 2022 offered 137 men an individualised regime emphasising increased physical activity and an adherence to the "Mediterranean diet", which incorporates many of the components thought to benefit fertility. After four months, they experienced significant improvements in sperm quantity and quality compared with people in the control group

Given that diet and exercise often go hand in hand when it comes to lifestyle interventions and good health, you might think that exercise would be firmly linked to better sperm. In reality, however, it isn't so straightforward.

Small studies have shown some increases in the health of sperm with moderate exercise, such as 30 minutes of cardio, three times a week. Likewise, a recent study showed that men who lift heavy objects at work had a 44 per cent higher sperm count compared with those who had less physical jobs. They also had higher testosterone and oestrogen levels, which have been associated with better general hormonal balance. However, other studies suggest that you shouldn't overdo it. For instance, sperm health decreases after a period of rigorous exercise, such as trekking up a high mountain for 6 to 8 hours a day for five days, or after intensive cycling training for 16 weeks. A larger study of cyclists found no link with fertility (see "What causes sperm decline? Fact and fiction", left), but more evidence is needed to say for sure.

So, where does that leave us? "If you think of what a doctor would tell you to change to improve your heart health, you're also going to improve your sperm health," says Swan.

It has been 50 years since Nelson and Bunge first announced their findings. While today's researchers may still debate the specific causes, consequences and cures of sperm decline, they are united in one opinion: the urgent need for a greater understanding.

"It deserves a lot of attention," says Boulicault. "Reproductive health is a really important part of people's lives and that means that the way we do the science has to be extra vigilant and robust."

Swan compares it to the climate crisis. "We're following the same path," she says. "You have the first warnings, then you have the big wave of denial, then you have more people agreeing that it is getting worse."

Next comes the hard part: taking action. The clock is ticking – and future generations may judge us for the decisions we make today. ▮

David Robson is a science writer and the author of *The Expectation Effect: How your mindset can transform your life*. He is based in London

# The back pages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## Debunking gardening myths

# What's at stake?

New Year, new tree? You can ignore advice to anchor your sapling – and get better results in the process, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek


IF ONE of your New Year's resolutions is to be kinder to the environment, you might start by planting a tree – it is one of the simplest ways you can make a small but meaningful difference to your local area. However, if you are a newbie looking up how to do this, you will soon encounter one of horticulture's most contentious issues: should you add a stake to help support your new sapling, or leave it au naturel?

Wander around almost any area with newly planted trees and you will see how widely the former is used, from tripods of metal poles to elaborate constructions of guide ropes, pairs of giant wooden stakes and specialist rubber ties – even invisible underground anchoring devices. But the strange thing is just how long ago scientific trials reported this practice to be counterproductive.

We have known since the 1960s that staking trees alters their normal development. In nature, the rocking motion trees experience when buffeted by winds triggers them to grow stockier trunks and deeper roots. It is a fascinating phenomenon known as thigmomorphogenesis.

Staking not only reduces the overall movement of the tree necessary for this reaction, but also focuses the bending at the point immediately above the tie to the stake. This means that instead of developing stout bases that slowly taper toward the top of the tree, staked trees often start to thicken only above the tie, creating inversely tapered trunks

BGFOTO/GETTY IMAGES

that are thinner at the bottom. As soon as these stakes are removed, according to some studies, the top-heavy trees can no longer support themselves.

We also know that ties can cause significant harm to trees – even death – by strangling the flow of water and nutrients through their trunks as they grow, and making them susceptible to infections. This kind of damage is extremely common, affecting over a third of all the sampled trees in London, according to one study. This combination of factors is why researchers at institutions including Washington State University and Pennsylvania State University have labelled the idea that staking newly planted trees is necessary as a myth.

It is important to point out that a few studies have found that staking, if used for a very short period of time (around a year or so after planting), can have some beneficial effects. These include reduced incidence of tree stunting, pests, diseases and even death. However, the same team also found that this only seemed to be the case for public tree plantings maintained by professionals, with the inverse true for private gardeners, who generally failed to remove the stakes at the correct time.

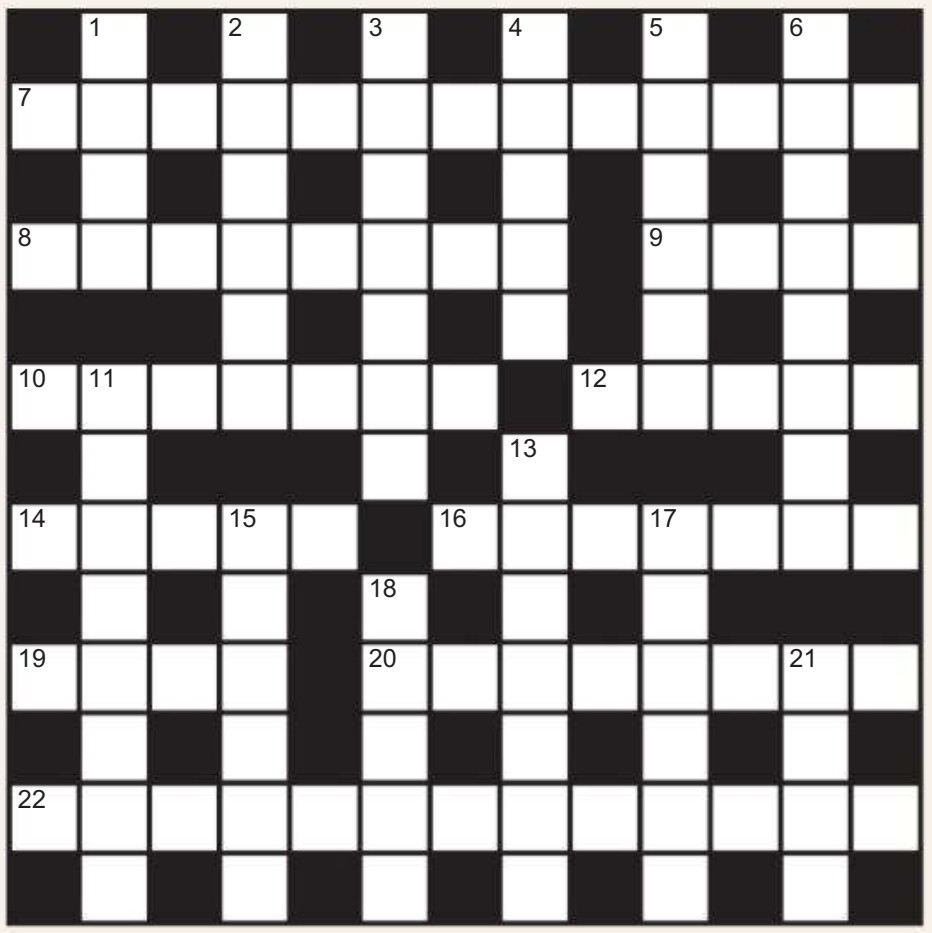
So, for most home growers, the science is pretty clear: skip this laborious step and get better results. You're welcome. ▮

*Debunking gardening myths appears monthly*

**Next week**
Science of baking

**These articles are posted each week at newscientist.com/maker**

## Cryptic crossword #127 *Set by Trurl*



**Scribble zone**

Answers and the next quick crossword next week

**ACROSS**

**7** It's highly complex, rebooting modern tablets! (10,3)
**8** Singer giving back precious stone, getting rid hastily (8)
**9** Look within, and kiss Bradbury? (1-3)
**10** Silky top put in wardrobe is most intimate (7)
**12** Twitter dead: to begin with (it might have a bounce) (5)
**14** It may take practice to get majority of British exhausted (5)
**16** Sailor single-handedly finding sea snail (7)
**19** Old soldier has love for boycott (4)
**20** A doctor's funny little creature (8)
**22** Socialist to initiate clandestine units – they keep iron in circulation (3,5,5)

**DOWN**

**1** Crockett Sr isolated by him (4)
**2** Where to get milkshakes without Jack (6)
**3** Low grade upset rising primary education curve (7)
**4** 'E was carried to eat (5)
**5** Coordination problem overcome by extra taxi arrangements (6)
**6** Roughly when you should be there, by sea, with top off, seeing whale, possibly (8)
**11** Knight expressing love and getting Guinevere, at last – it's a little fishy (8)
**13** Live up on unmanageable debit, reaching a low point, mainly? (3,4)
**15** "Most of x + x" is Bing result? (6)
**17** Goes for salad (6)
**18** Place in Panama: part of canal (5)
**21** Regularly, jovially glib (4)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #235
*set by Bethan Ackerley*

**1** In geology, rocks rich in magnesium and iron are known as what?

**2** Who is the 1956 experiment that disproved the conservation of parity in particle physics commonly named after?

**3** Which of our solar system's known moons has the most eccentric orbit?

**4** What are the forces that attract neutral atoms together in a gas?

**5** Which of the following plants isn't a member of the Rutaceae family: the curry tree, the orangeberry or the jackfruit?

*Answers on page 47*

## BrainTwister
*set by Katie Steckles*
### #3 Page turner

**When printing books, the page numbers are included in the corner of each page.**

**If a book has 24 pages, how many digits are used in printing all the page numbers?**

**If a book uses 183 digits in printing all the page numbers, how many pages does it contain?**

**If another book uses 636 digits in printing all the page numbers, how many pages does it have?**

*Solution next week*

## Full stop

**If Earth stopped rotating, would this affect the force of gravity?**

***Chris Daniel***
*Glan Conwy, UK*

When Earth rotates as normal, the centripetal acceleration of the ground under your feet at the equator has the net effect of reducing the force of gravity on you, so you weigh about 0.3 per cent less than would be the case with gravity alone. This effect decreases with distance away from the equator and becomes zero at the poles. The centripetal acceleration is always perpendicular to the axis of Earth's rotation and points away from the local vertical towards the equator by an angle equal to the latitude.

In London, for example, which is at a latitude of about 51 degrees north, the combination of gravity and the centripetal acceleration means that you have to lean to the north by nearly a tenth of a degree to maintain your balance. However, you don't notice this because everything else is also aligned to this apparent local gravitational direction. If Earth stopped turning, you could happily return to a perfectly vertical position with the centre of the planet directly beneath you.

**"If Earth grinds to a halt, the oceans will overwhelm the land as water is driven in an easterly direction by the deceleration"**

Earth is, as we are taught, an oblate spheroid, which means it bulges at the equator due to its rotation. Here, its diameter is about 42 kilometres greater than at the poles. This means that the gravitational acceleration at the equator is slightly less than elsewhere because it is further from the centre of Earth. If our planet stopped spinning, it would gradually assume a more spherical shape and gravity would be the same everywhere apart from local variations due to Earth's non-uniform geology and topology.

However, if it were stationary, the effects on the force of gravity would be the least of your worries. If, say, Earth grinds to a halt over 24 hours, the horizontal deceleration at the equator would be equivalent to about one-two thousandth that of gravity as the rotational velocity goes from about 1670 km/h to zero. While this may not be very noticeable to you, the stress on Earth's crust could create earthquakes and large surface movements such as landslides. Even more seriously, the oceans would begin to overwhelm the land as water is driven in an easterly direction by the deceleration of Earth underneath it. At the equator the forces on it would be about 5000 times greater than the tidal forces due to the moon.

Weather patterns and ocean circulation caused by Earth's rotation and diurnal temperature variations would quickly cease. The side left facing the sun would exceed the boiling point of water and the dark side would lose heat into space, cooling enough to cause nitrogen and oxygen to freeze. Life probably wouldn't survive anywhere. A spinning Earth is better for all of us.

***Ron Dippold***
*San Diego, California, US*

Gravity itself would be unchanged, but things would seem slightly heavier. When Earth is spinning normally, things at the equator experience the normal pull of gravity, but there is a centrifugal force counteracting it, like someone hanging off a spinning playground roundabout feels they are being pulled away from the centre. Because of this, things at the equator (which is rotating at about 1670 kilometres an hour) experience a 0.34 per cent apparent reduction in the force of gravity. This effect falls off as you go further north or south, of course. Things at latitude 60 degrees are "only" going about 840 km/h and the rotation isn't perpendicular to Earth's surface, so their apparent weight is reduced by about 0.08 per cent. At the poles, the impact is zero.

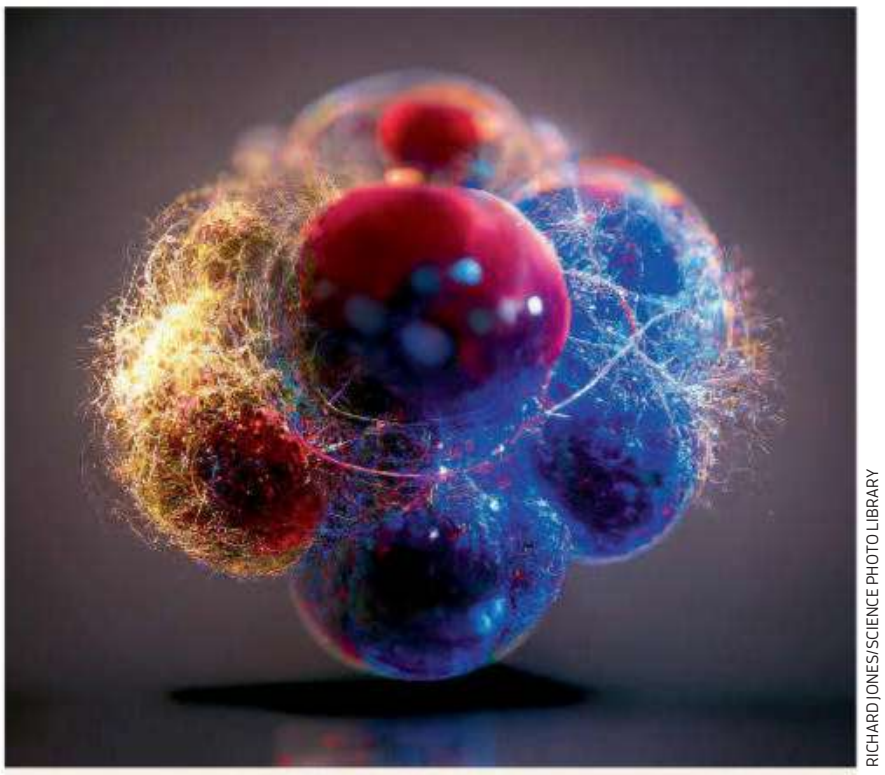
This is known as the Eötvös effect, after Hungarian physicist Baron Loránd Eötvös, who noticed in the early 1900s that sensitive gravity readings on ships travelling east were higher than on ships travelling west. You are noticeably (with sensitive equipment) changing your apparent gravity when you drive east or west because you are changing the speed at which you are "orbiting" Earth!

Finally, if Earth stopped rotating instantly, most things would be dead anyhow, because 1670 km/h to zero is a hard stop. If you didn't go splat, the firestorms (from 1670 km/h winds) and tsunamis (1670 km/h water) would get you. People at Antarctic bases would be spared (for a while), and they wouldn't feel any heavier. Some people have all the luck!

***Herman D'Hondt***
*Sydney, Australia*

In short, it would have no effect on Earth's gravity, as it is only caused by mass. As Earth's mass doesn't change when it stops rotating, its gravity wouldn't either.

However, for an observer on Earth, the reality would be (slightly) different. As Earth rotates once every 24 hours, we are subject to a centrifugal force (or rather, an



RICHARD JONES/SCIENCE PHOTO LIBRARY

## This week's new questions

**End of the matter** **What happens to the electrons, protons, neutrons and photons that exist in living beings when they die?** ***Andrew Pipkins****, Forney, Texas, US*

**What a twist** **All the climbing plants and weeds in my garden twine anticlockwise. Is there an evolutionary advantage to this? And do any twine clockwise?** ***Peter Waller****, Bristol, UK*

What becomes of bodily subatomic particles and photons when we die?

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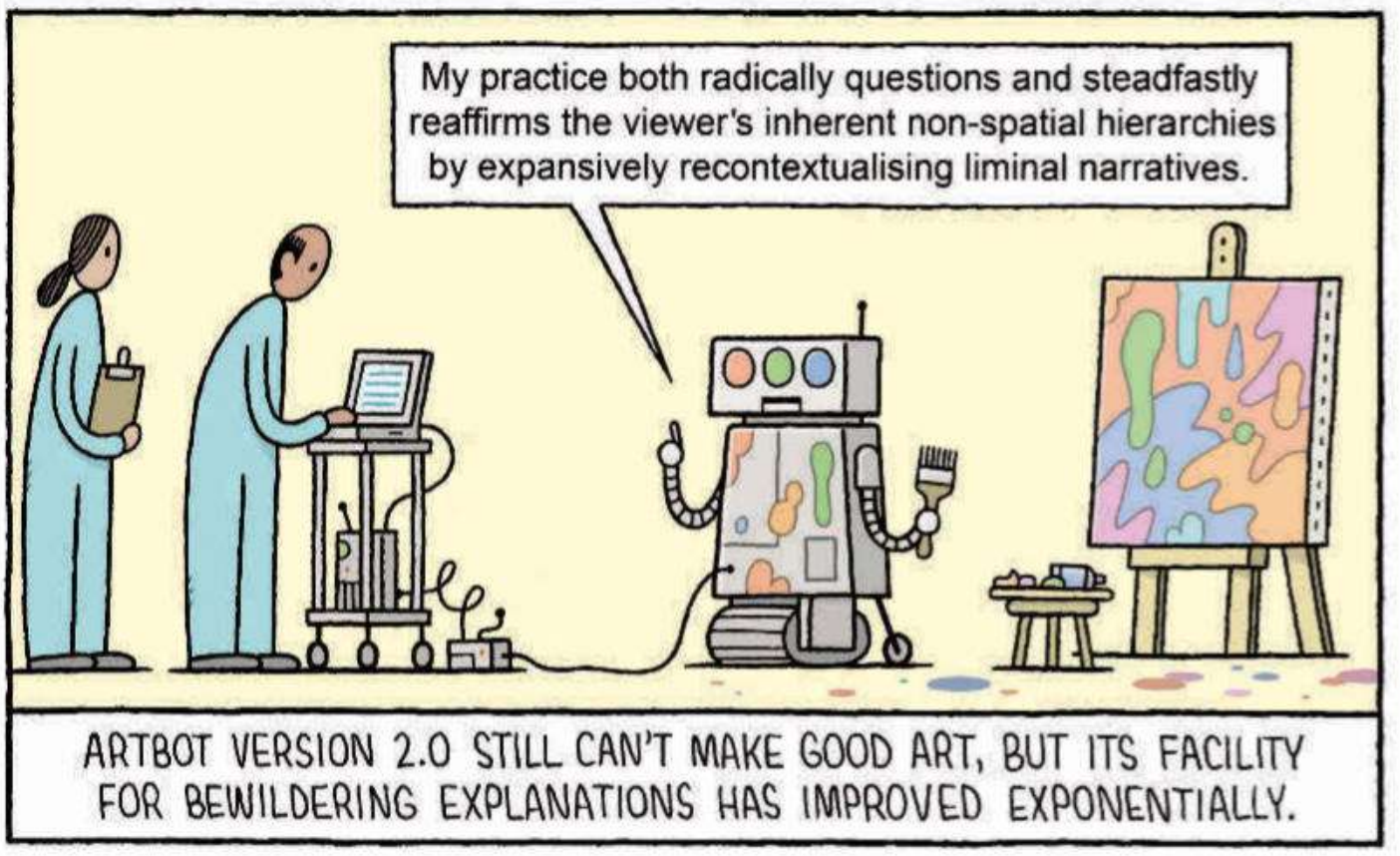
**Tom Gauld**
*for New Scientist*


My practice both radically questions and steadfastly reaffirms the viewer's inherent non-spatial hierarchies by expansively recontextualising liminal narratives.
ARTBOT VERSION 2.0 STILL CAN'T MAKE GOOD ART, BUT ITS FACILITY FOR BEWILDERING EXPLANATIONS HAS IMPROVED EXPONENTIALLY.

inertial force), pushing us away from Earth. This is largest at the equator and zero at the poles. Hence, if rotation stopped, a person at the equator would feel slightly heavier and the reduction would diminish to zero as they got closer to either of the poles.

Because of this, an 80-kilogram person at the equator, who usually feels a gravitational force of about 785 newtons, would feel an extra force of 2.5 newtons. In other words, our guinea pig would feel about 0.3 per cent heavier – without any change in their mass.

## Too cute

**Why do we say "aww" when we see small, fluffy things?**

***Mark Thompson***
*Tewkesbury, Gloucestershire, UK*
This instinctive or emotional response is often related to a few psychological and evolutionary factors. Humans are wired to find certain features adorable, such as big eyes, small noses and soft fur. This is often referred to as the

**"When we see something cute, our brain triggers feelings of affection and a desire to nurture and protect"**

"cuteness response". These features trigger nurturing instincts and elicit a positive emotional response.

The instinct to care for and protect small, vulnerable creatures is deeply ingrained in human behaviour. When we see something cute, our brain will trigger feelings of affection and a desire to nurture and protect, which is expressed through the verbalisation "aww".

Throughout human evolution, care and protection of offspring were crucial to the survival of our species. Responding positively to cuteness played a role in ensuring that caregivers were attentive and protective of their young, enhancing the chances of survival for the next generation.

We aren't alone in this; most mammals evolved this way for the protection of their young. After all, the common ancestor of all mammals appeared around 200 million years ago during the Late Triassic period. It was a small, shrew-like, insect-eating tetrapod. That is a lot of time to evolve the aww reflex.

## Plunging in

**When going swimming in the sea, is it better (scientifically, emotionally or spiritually) to enter quickly or to take your time? (continued)**

***Crispin Piney***
*Mougins, France*
Although I wouldn't attempt to argue with cold water swimming clubs that say enter with caution, this advice seems at odds with the Scandinavian practice of running from a boiling hot steam room to plunge into an ice-cold bath. People seem to enjoy the experience and prosper from it. Is this, as Roman poet Juvenal might have put it, a matter of "men's sauna in corpore sano"? ▮

## Answers

### Quick quiz #235 *Answers*

**1** Mafic

**2** Chien-Shiung Wu, who led the experiment

**3** Nereid, a moon of Neptune

**4** Van der Waals forces

**5** The jackfruit

### Quick crossword #149 *Answers*

**ACROSS 1** Command module, **10** Rotor, **11** Logarithm, **12** Tolerance, **13** Cling, **14** Mu waves, **16** Iron man, **18** Tea tree, **20** Equator, **22** Crewe, **24** Estradiol, **26** Angleworm, **27** Inion, **28** X-ray astronomy

**DOWN 2** Outflow, **3** Mars rover, **4** Nylon, **5** Magnetite, **6** Dirac, **7** Lithium, **8** Arithmetician, **9** Imaginary line, **15** Steve Jobs, **17** Ovulation, **19** Avenger, **21** Tritium, **23** Emery, **25** Timer

### #2 Piles of money *Solution*

With six tokens, the maximum winning total is £9 (3×3).

For 10 tokens, this total is £36 (3×3×4).

In general, you should make piles of as many 3s as you can, then either a 2 or a 4 (or equivalently, two 2s) with what is left.

## Threatened masculinity

**Psychology research procedures can be innovative and intricate, especially in the US. A study called "Examining the effect of threatened masculinity on gun violence" by Brittany Vincent and her colleagues at St. Joseph's University in New York showcases these qualities.**

**This research is planned to happen in four stages. First, the study says, "each participant will be given a baseline assessment of their masculinity". Then each participant will be told about a difficult moral dilemma and asked how they would solve it. They will be informed that another participant will read their response and will give them "an audio recording about what they think of their response".**

**It is at this point that things get interesting: each participant will then "either have their masculinity threatened or be assigned to a control group".**

**In the final stage, the interestingness continues to grow: "participants will be asked to play a game involving an online voodoo doll where they will be asked to pretend the voodoo doll is the person from the recording, and to shoot the voodoo doll".**

## A bunch of points

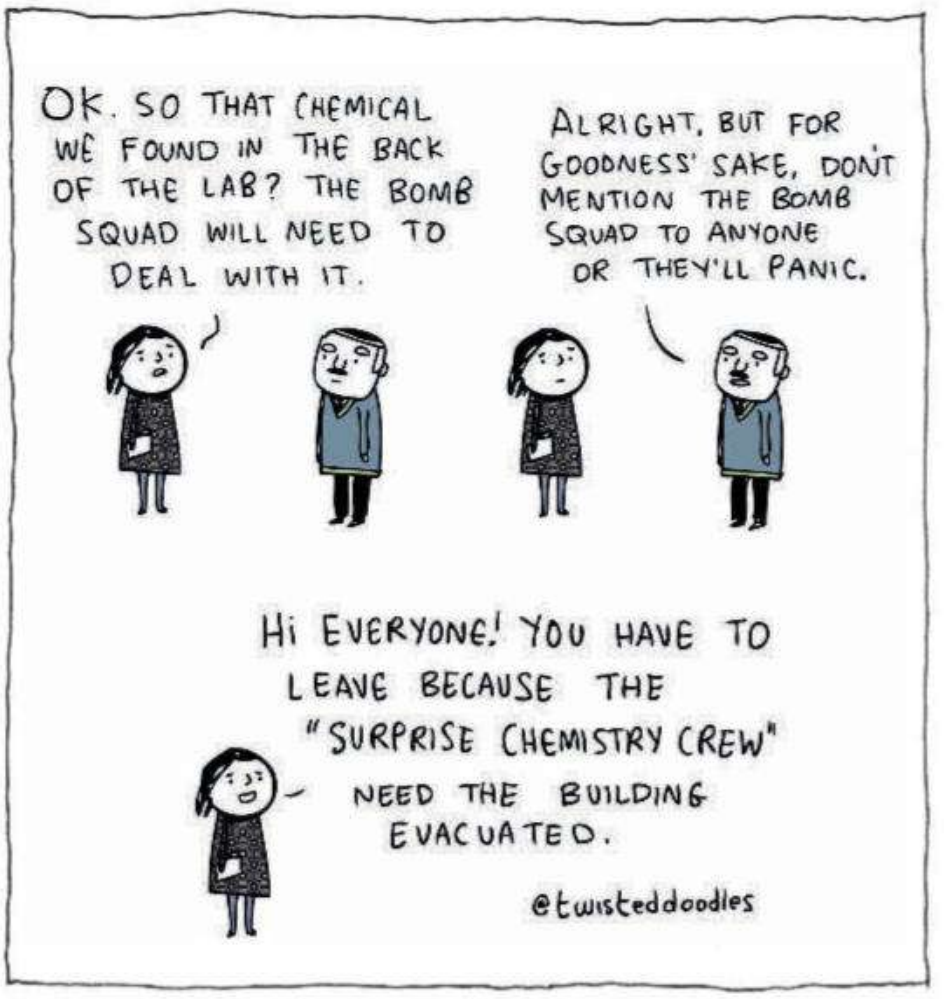
Mathematician Ravi Vakil at Stanford University in California wrote a phrase you might apply to lecturers who ramble at whim – who flit yon, thither and hither as they tell some simple fact.

Vakil gave a talk earlier this month called "Passing a curve through *n* points – Solution of a 100-year-old problem" at the Joint Mathematics Meetings 2024 in San Francisco.

He asks a purely mathematical question that (Feedback suggests) harks of a familiar human behaviour. It seems to describe the way some lecturers yearn to meander en route to their destination. Vakil asks: "Through two randomly chosen points in the plane, indeed in *n*-space, there is a line [but] is there a curve of some 'type' through a bunch of generally chosen points?"

For lecturer and listener alike, the basic question sometimes is: "What's the point?"

## Twisteddoodles *for New Scientist*


OK. SO THAT CHEMICAL WE FOUND IN THE BACK OF THE LAB? THE BOMB SQUAD WILL NEED TO DEAL WITH IT.
ALRIGHT, BUT FOR GOODNESS' SAKE, DON'T MENTION THE BOMB SQUAD TO ANYONE OR THEY'LL PANIC.
Hi EVERYONE! YOU HAVE TO LEAVE BECAUSE THE "SURPRISE CHEMISTRY CREW" NEED THE BUILDING EVACUATED.
@twisteddoodles

### Got a story for Feedback?

**Send it to feedback@newscientist.com**
**or New Scientist, 9 Derry Street, London, W8 5HY**
**Consideration of items sent in the post will be delayed**

## Sedate entertainment

**John Davies, a retired anaesthetist, responded to Feedback's query (9 December 2023) about the saying that "the art of medicine consists mostly of amusing the patient while nature cures the disease". The expression is, correctly or not, often attributed to Voltaire.**

**John says: "Voltaire was not a doctor, but a hypochondriac. So of course he knew what he was talking about. But he was 'practicing' in the 18th century, when medical treatment was either herbal or bleeding, and surgery was either military or dental, because it was so painful. Today we have drugs which are undoubtedly effective, and because of anaesthesia, painless surgery during the procedure.**

**"But amusing the patient? During surgery under general anaesthesia, no patient amusement is required, and keeping the surgeon amused and in good humour is the best service the anaesthetist can provide for the theatre staff. Stories, chat and anecdote all help.**

**"Surgery under local anaesthesia demands the same amusement for the patient. And what you learn! Under mild sedation, as under mild intoxication, all sorts of stories come out about their lives, none of which may be repeated, of course."**

## 'Masterly inactivity'

Gavin Spickett, a retired consultant in medicine, immunology and allergy, also gave his perspective on the saying:

"One patient, an elderly gentleman who lived alone and had no family, was admitted regularly when I was a junior doctor. His illnesses were nebulous and most likely to be generated by a desire to be in hospital to be warm and well fed. He was undoubtedly lonely. On admission, he always insisted on Guinness and 'red medicine'. He would never improve until supplied with his preferred treatment...

Once this was prescribed and accompanied by the nurses making a fuss of him, there was always a steady improvement... leading to a willingness to be discharged. The red medicine was an iron edetate syrup (bright red!), to which he ascribed magical properties, even though he wasn't deficient in iron. Subsequently I found that this syrup was equally effective in other patients during my career.

"[Long ago] a highly respected clinician, for whom I was working, explained that if you were not sure what was wrong or what treatment to give, then you should give MICLO therapy. MICLO stood for 'masterly inactivity and cat-like observation'. Doing nothing beyond following the patient carefully and supplying empathic holistic care is still sometimes both appropriate and necessary, but is at risk of being buried by the avalanche of new genetic tests, imaging techniques and bespoke pharmaceuticals."

## Tiny truths

**Alison Flood, *New Scientist*'s comment and culture editor, offhandedly came up with a good new definition for medicine: "quite gross – but also interesting".**

**Those five words remind Feedback of biologist Dany Adams's classic seven-word definition of biology: "If it can get infected, it's biology." Can you come up with a pithy new definition (of seven or fewer words) for some scientific concept? If so, please send it to: "TINY TRUTHS" c/o Feedback.**

*Marc Abrahams*

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